# SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • October 28, 1958

# SCIENCE HOMEWORK

Asked the purpose of homework, one student said, "It's to keep us busy." Indeed, a good many students fail to grasp the real purpose of homework: to continue the learning process after school hours. It is up to the teacher to keep reminding students of this.

Science, in particular, lends itself to a large variety of homework activities that are really extensions of the classroom lesson. Because of this variety, the science teacher must make a special effort to see that students don't lose sight of the purpose of homework. So, before going into types of homework assignments, let us consider certain strategic factors that should be kept in mind when assigning homework.

First, it is important that students know specifically what the assignment is and why it is being done. Frequently, the assigning of homework is left until the end of class. In some cases, it is written on the blackboard before the students come in. If these methods are used, it is essential that the students know how and why the assignment fits into their learning situation.

Most teachers prefer to give an assignment that continues a classroom lesson. However, there are times when homework is intended to prepare students for the next lesson or series of lessons. Wherever possible, students should know the aim of this type of assignment, just as they should understand the aim of a classroom lesson.

It goes without saying that homework should be checked for completion and accuracy periodically. Otherwise, it won't be done properly or perhaps won't be done at all. In chemistry and physics, where the homework may involve the solving of problems, checking is particularly important. For it will reveal those youngsters who need help.

Any assignment that is worth giving is worth making interesting. And if it is not made significant to students, it probably won't be interesting to them. An assignment such as, "Do problems 1 through 5 on page 507" is not significant unless the student sees the relationship of those problems to the present lesson or the next one.

### Kinds of assignments

An assignment may consist merely of completing a notebook write-up of a laboratory or classroom experiment. But this takes time and thought. It is often wise, therefore, not to add additional work, unless absolutely necessary as preparation for the next lesson.

If a reading assignment is given, the students should know what to look for in the reading. Four or five strategic questions will help them. Some textbooks contain such questions. It is up to the teacher to select those questions that will best serve the purpose.

Simple experiments can often be done at home, and the observations and results brought in. In this way, much data can be gathered by a class.

The assignment may be a report on a radio or TV science program that is related to the classwork. Or it may be a report on a science book. Such reports can be given orally or in writing. Short written reports on science books can be passed from one student to another. In that way, students will have an opportunity to read reports on many different science books.

An occasional assignment might also include short readings in and reports on the original writings of such men as De Coulomb, Harvey, or Lavoisier. The writings of many famous scientists can be found in inexpensive paperback books. Some teachers buy sets of these books for the use of their classes. Reports can also be made on current topics related to the particular subject being studied.

Some teachers require that a student submit one or more reports a year or a semester. It is important that these be extensions of the classwork and not repetitions. And the teacher should make clear what such a report should cover. A sample report given by the teacher is a help. The report itself, if oral, should be about five minutes long — certainly not more than ten. Speaking notes should be on cards. Students should be encouraged to use illustrations, such as charts, chalk drawings, homemade slides, or enlarged photographs. These help clarify various points and make for brevity. And the teacher should stress the proper use of language.

As the student gives the report, he might well write new words and their meanings on the blackboard. Finally, he should summarize.

In assigning homework, the teacher has to keep in mind the more capable students. In addition to the regular assignment, they can be given a more difficult, optional assignment. Since any science textbook is out of date by the time it is off the press, the optional assignment may be used to supplement the text. Reports on articles in SCIENCE WORLD and other publications can serve this purpose.

An approach to individualized instruction can be made through projects. The word "project," unfortunately, has come to have many meanings. Projects may range from

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# TEACHER'S TOOLS

HAGAN CHEMICALS & CONTROLS, INC., offers teachers a handy water-softening kit without charge. The kit consists of the "Calgon Speedy Kit," a rinse demonstration, "handkerchief test," and city-water hardness demonstration. Accompanying literature gives full details and describes other tests that can be done with Calgon (sodium hexametaphosphate). (*If you want the water-softening kit, Check* 1028*A*.)

THE DU PONT MAGAZINE is ideal for the chemistry and physical science classroom reference reading shelf and bulletin board. Each issue contains several fascinating articles suitable for student reports and subject-matter background. The regular feature, "It's New," paces most other printed matter, with new product items utilizing the latest in scientific research and development. Upon request, science teachers are placed on the magazine's mailing list without charge. (*If you wish to receive the Du Pont Magazine, check* 1028*B*.)

EDMUND SCIENTIFIC COMPANY meets the growing science education need in astronomy with its Spitz School Planetarium. The portable projection dome cover, consisting of 28 segments, is 10 feet in diameter. Easily set up by two people in less than 15 minutes, the dome is completely adjustable in height to 6 feet 3 inches (perimeter to floor). The star projector is gear-driven to give daily motion equivalent to one day every four minutes. Included with the equipment is an arrow-pointer, meridian projector, dome illuminator, and sunrise-sunset attachment. Using small chairs, as many as 35 students can be seated under the dome. (*Check No.* 1028C *for further information on the Spitz School Planetarium.*)

FORMA SCIENTIFIC, INC., introduces a new concept in lab equipment with its Portable Incubator No. 3400, "Iso-Mite." A boon to the study of bacteriology and immunology in advanced high school courses, the incubator comes complete with Petri dish rack holding 12 standard 100 x 15 mm dishes, dovetail muff and clamp for wall mounting (if desired), special thermometer, and red bulbs. Weight of entire item is three pounds. (*For more information, check* 1028*D*.)

E. H. SHELDON EQUIPMENT COMPANY pays special attention to Junior Science Furniture in a new 1958 catalogue. Stressing the Sheldon Life Experience concept, the new catalogue gives several science-facility plans for the junior high school. Floor and equipment plans are suggested for the study of the earth, chemistry, electricity, heat, sound, living things, light, and mechanics. (*If you want the catalogue, check No.* 1028*E*.)

### 'Tools' question box

*Any questions on teaching tools? Send them to: 'Tools' Question Box, Science Teacher's World, 575 Madison Avenue, New York 22, N.Y.*

**A.B.B., New York, N.Y.: "Where can I find the latest and best information on 'what's really new' in nuclear energy?"**

*Answer:* Obtain a copy of the United States Atomic Energy Commission report, *Research on Power from Fusion and Other Major Activities in the Atomic Energy Programs* (*January-June*, 1958). This book is available for $1.25 from the U.S. Government Printing Office, Washington 25, D.C.

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**Homework *(Cont. from p. 1-T)*** constructions to library research to small-scale experimental research by students. But whatever the type of project, the student needs constant help from his teacher and others — teachers of related subjects, parents who are practicing scientists, hospital personnel, scientists in a local industry, college, or research laboratory, etc. Some teachers insist that every student do one project. But, in the estimation of many teachers, this may be a self-defeating process.

For exceptionally qualified students, some teachers use a more advanced text. The talented student is assigned the same topic as the class, but he studies it in the advanced rather than the regular text. The teacher, of course, must monitor his work independently from that of the rest of the class.

As teachers are well aware, there is no one way to give assignments. This is all to the good. Variations in assignments increase interest and motivate class work. It is up to the teacher to select those variations that best suit his own students and teaching conditions. Teachers who have fresh, interesting ideas along these lines may want to submit them to "Shop Talk" (see page 6-T).

# MEMO

## To: Science teachers

### Subject: Ways to use this issue of SCIENCE WORLD in the classroom

#### Changing heat into electricity

PHYSICS AND GENERAL SCIENCE TOPICS: thermoelectricity, energy transformations, thermionic emission

Many students will be intrigued by this new development — the changing of heat *directly* into electricity. They can compare the boiling off of electrons in the thermionic converter to the similar, but smaller-scale, action in the filaments of radio tubes. An efficiency of 8 per cent — achieved by the converters — is actually very high. Early steam engines had an efficiency much lower than this. Students may want to try some of the experiments presented in connection with the article.

Class discussion

1. How would this device simplify the construction of electric power plants?
2. How might you produce electricity with a candle?
3. In which direction do the electrons move inside the device?
4. Where do the flow-producing electrons come from?

Experiments and projects

1. Perform the related experiments in this issue of SCIENCE WORLD.
2. Demonstrate the Thomson Effect by pivoting a small aluminum disk on a needle point. A small dent in the exact center of the disk will serve as a pivot. Place a strong magnet just above the disk's edge and heat the disk with a candle. The disk will turn. Reason: electric current is produced by the heat, and a magnetic field is formed. This is repelled or attracted by the magnet's field.

#### The researcher as a man

BIOLOGY AND GENERAL SCIENCE TOPICS: research as a career, cancer

This article is particularly useful as guidance material. It will open the eyes of students to the work of a scientist — in this case, a researcher in anti-cancer chemicals. Students will receive an inside view of the problems, the successes, and the failures of the researcher in this field. They will see how one idea leads to another and how the training of a scientist enables him to explore new avenues when a clue does show up. In many ways, this is a highly inspirational article. It will also serve as source material for a discussion of the nature of cancer in biology or general science class. When studying cancer, you may also wish to ask your local chapter of the American Cancer Society for booklets or display material for secondary school use.

Discussion problems

1. How are anti-cancer chemicals tested?
2. Why is the search for anti-cancer chemicals so costly in time and in money?
3. Why is cancer such a difficult disease to attack?

Experiments and projects

1. Invite a cancer expert to speak to your class.
2. Examine plants for tumors, such as galls, etc. These are very common.
3. Show cancer films made by the American Cancer Society.

#### Report on IGY

EARTH SCIENCE TOPICS: atmosphere, aurora
PHYSICS TOPIC: cosmic rays
GENERAL SCIENCE TOPICS: atmosphere, space travel

This article surveys some of the areas in which IGY scientists are working. It delineates the reasons why these areas are being investigated. And it clarifies the role of the hypothesis in science. Students will be particularly interested in the investigation of the auroras and of the hazards to future space travelers.

Class discussion

1. Why are IGY scientists studying the earth's atmosphere so intensively?
2. Why does the intensity of radiation in the polar atmosphere differ from that at the equator?
3. On what two hazards of space

flight have earth satellites provided important data?

4. How are satellites gathering information for IGY?

Experiments and projects

1. Use a borrowed Geiger counter to detect cosmic rays. A sheet of lead placed around the Geiger tube will stop all radiations other than cosmic rays.

2. Place an aneroid barometer or an altimeter inside a widemouthed jar, fit a tube through the cover, and pump out air with a hand vacuum pump. Observe the readings of the instrument. If you are using the barometer, try to determine the altitudes at which these pressures would occur. If you are using the altimeter, work out the pressures from the altitude readings.

3. Examine cosmic-ray tracks as illustrated in some advanced physics text.

4. Build the cloud chamber described in the September 28 issue of SCIENCE TEACHER'S WORLD. Use it without a radium source to observe cosmic-ray tracks.

## Marksman of the darkness

BIOLOGY TOPICS: birds, hearing
PHYSICS AND GENERAL SCIENCE TOPIC: sound

This is a remarkable story of how scientists formulate hypotheses and then test them, eliminating those that do not stand up. The main question the scientists tried to answer was whether owls hunt by ear. They also wanted to know whether any minimum light conditions were necessary for an owl to hunt for food.

Students should note: (1) the use of the control in this scientific research; (2) the ability to "put questions to nature"; (3) the technique used in forcing nature to answer the questions; and (4) the excellent examples of problem solving and of scientific reasoning.

The end of the article shows the student that sometimes additional observations are required to reach a conclusion and that the existence of more than one variable — in this case, light and special sound frequencies — prevents a precise and final conclusion from being drawn.

The article is sufficiently controversial in a scientific way to produce much class discussion. A science teacher who bases a one-period organized lesson on the material will find the time well spent.

Class discussion

1. Why is it difficult to give a final answer on how owls hunt their prey?

2. Why is it incorrect to assume that experiments with one owl can explain the hunting habits of all owls?

3. Why was it necessary in the experiments to build a "jungle" for the mice?

Experiments and projects

1. If you can borrow an audio oscillator from a local radio repair shop or radio experimenter, use it to have the class listen to sound waves of the frequencies that owls hear.

2. Use the audio oscillator to test the hearing range of the class.

3. Borrow a pet bird, such as a parakeet or canary, from a student. With a musical instrument, such as a violin or clarinet, try to find out the highest notes to which the bird responds.

4. Borrow an oscilloscope. Connect it to a public address system equipped with a microphone. Set a Galton whistle above the human hearing range and blow it. Then observe the ultrasonic wave patterns on the oscilloscope.

5. Use a Galton whistle and a dog to demonstrate the fact that a dog hears frequencies above those heard by the human ear.

## Gateways to the mind

BIOLOGY AND GENERAL SCIENCE TOPICS: senses, nervous system, eyes, taste, reflex centers, brain

This article presents new and frontier-developing knowledge. It can be used to extend the material on the five senses usually presented in biology or general science textbooks. Scientists have found that there are at least fourteen distinct senses. The reader will learn something about the methods used by research scientists to study these senses.

The article can be used to extend the classwork for all topics usually studied under the general subject of the nervous system. The student will find the work on the brain's "memory bank" especially stimulating.

The article is based on the new Bell System TV film. This film, like others in the Bell Science Series, is available on loan to schools without charge. Contact your local Bell Telephone Business Office.

Class discussion

1. Why can we say we have fourteen rather than five senses?

2. What are the fourteen senses?

3. How does the "memory bank" work?

4. How do the eye and the brain work together?

5. Why do we react to pain before the pain signal reaches the brain?

6. How do we know that certain areas of the brain have information stored in them?

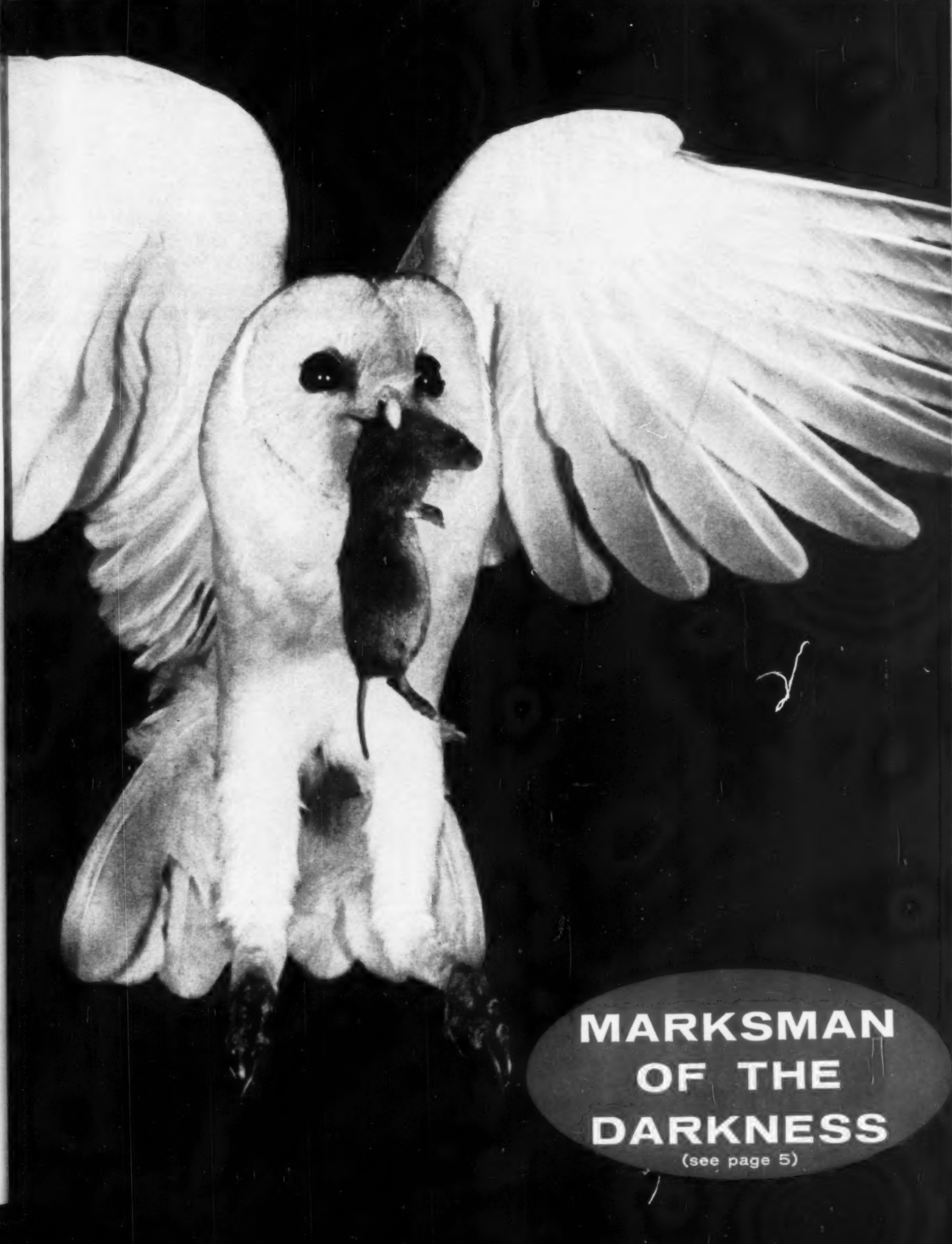
Experiments and projects

1. Mix solutions of salt, sugar, vinegar, and dilute quinine water. Dip sterile cotton-tipped swabsticks into these solutions, and try to locate the salt, sweet, bitter, and sour taste areas on a student's tongue. Do not use a swabstick more than once. Make a map of the tongue to show the location of these taste areas.

2. Demonstrate the blinking reflex by having a student hold a sheet of cellophane in front of his face, while another student tosses a small wad of paper at it.

3. Demonstrate the pupillary reflex as follows: Have students observe the size of the pupils of each other's eyes in a well illuminated room. Then have each student cover his eyes for ten minutes, uncover them, and look immediately at the dilated pupils in his neighbor's eyes. As minutes pass, they will observe the gradual contraction of the pupil as the eye becomes accommodated to the light. A single student can demonstrate this to himself with the aid of a mirror.

SCIENCE WORLD
THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS



MARKSMAN OF THE DARKNESS

(see page 5)

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# SCIENCE WORLD

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## Coming in SW November 11

What is the "red tide" that attacks and kills huge numbers of fish?
Why is John Dalton considered the world's first atomic scientist?
How are geologists drawing on botany to find new mineral deposits?
Can you observe Newton's laws of motion in what you see about you?
What does it mean when howlers of the jungle suddenly fall silent?
For the answers, see *SW* November 11.

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### *Features*



### *Science Fiction*



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## When readers write

Every day, *SW* receives a large bag of mail asking for certain kinds of help that, unfortunately, we cannot give. Even though we'd like to lend a hand, we cannot write reports on special subjects, outline science projects, or collect and mail out free booklets. Instead, we suggest:

For information on a subject: visit your local library. The librarian will be glad to help you find the books and magazines you need.

For science projects: see *SW's* "Young Scientists" feature, which runs in every issue. Choose one of the projects suggested there or think up your own variations on these ideas.

For free booklets: check over "Yours for the Asking" and request what you need.


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By Roger S. Payne and William H. Drury Jr.

# MARKSMAN OF THE DARKNESS

**Two zoologists report on their experiments showing how barn owls locate their quarry at night**

Any bird that sings should be able to hear its song. Biologists have shown that this is true — not only can a bird hear its own song, but the tones that it hears best are those near the middle range of all the various notes it utters.

This seems to be a general avian rule, but, like most rules, it has exceptions, and a notable exception is found in the case of owls. J. Schwartzkopff has shown that the long-eared owl (*Asio otus*), for example, can hear about the same tones that humans do. It is, however, most sensitive to tones high above the middle range of its own voice.

Why do owls have this strange ability to best hear notes that are so much higher than their own calls? It seems that there must be some reason, important in the lives of owls, which has made it necessary for them to hear high-pitched sounds.

We know, for example, that mice (which are important prey for many owls) squeak at about the same pitch at which owls hear best. Although mice probably do not squeak often enough to allow hunting owls to track them all down this way, they do make rustling and crackling sounds as they move through ground litter, and some of the component frequencies of these sounds are high-pitched. Can it be that owls, hunting in darkness, use their ears to locate mice? When the light is poor, even the best eyes would have difficulty in seeing a mouse move about in leaves or grass. But what about the ears?

There is a great deal of scientific evidence (based on their specialized ear structure) that owls must have exceptional hearing. The question seems to be: why?

In September, 1956, while Payne was at the Louise Ayer Hatheway School of Conservation Education in Massachusetts, the authors decided that it would be worth looking into this question. The late James L. Peters of Harvard's Museum of Comparative Zoology had suggested to Drury in 1947 that the reason for specialized ear structure in owls be investigated. A barn owl (*Tyto alba*) was donated to us by Dr. Winthrop W. Harrington of Lexington, Massachusetts, who had raised it from the age of a few days. This exceptionally tame bird was known, with apologies to A. A. Milne, by the name of WOL.

WOL had hunting and pouncing instincts, but, being hand-raised, he did not know what to hunt or pounce upon. He would peer at a picture on a newspaper page and then glide down and strike it with his talons. He seemed to strike at any small object that differed from its background. This well-developed hunting instinct, before he "knew" what to hunt, was an interesting aspect of animal behavior in itself. We set out to show him prey.

"WOL's House," as it was called, was a room about twenty-five feet by twenty feet, empty except for a seven-foot-high perch, a bathing trough, and a table in one corner, where we fed WOL when experiments were not going on.

The first time WOL saw a living mouse he flew down onto the floor near it. The mouse ran. WOL finally caught it, but only after a long chase — half-flying and half-running over the floor. The same pattern of chasing the mouse persisted for the next several trials until, one day, he flew from his perch and struck a mouse directly. This, a more normal hunting method, stayed with him, for he struck mice directly thereafter.

Having satisfied ourselves that WOL was capable of catching mice in true owl-fashion, we set up the equipment for our hearing experiments. We spread dry oak leaves on the floor. This meant that anything moving through the leaves on the floor could be heard. We boarded up the windows to make sure the room would be light-tight. We checked ourselves by exposing hypersensitive film for an hour when the lights were turned out; the film was developed and showed no trace of exposure. We thus felt safe in assuming that, no matter what animal we worked with, there would be no light for it to see by.

The preliminary to our next experiment was to make sure that WOL was "at home" in his quarters. It was very important that he know the whole room "by heart," so that he could later fly around in the dark. We gave him about five

*Adapted from an article that first appeared in* Natural History.

weeks to "memorize" his surroundings. During this time, we left a small night light on in the room, turning it off occasionally. During the last week before we started our experiments, and off and on during them, WOL was left in complete darkness.

Our first experiment was to release a wild-caught deer mouse (*Peromyscus leucopus*) on the leaf-strewn floor of the room, with the lights off. The mouse moved about, "exploring" the room and rustling the leaves. When the mouse stopped and was silent, we heard WOL leave his perch, fly down, and strike in the leaves. Quickly, we turned on the lights and found WOL standing motionless and holding the mouse in his talons. We tried this experiment seventeen times. When the mouse stopped (and, in our experience, *only* when it stopped) WOL flew. In all but four of these trials (which involved misses of no more than two inches), WOL successfully struck the mouse.

With no light available, WOL obviously was not using his eyes to find the mouse. This left four other possibilities: (1) he could be using his ears and homing on the sounds the mouse made; (2) he could be homing on the odor of the mouse; (3) he could be making his own sounds and using the echoes to guide him (echolocation), as some bats are known to do; (4) he could be "seeing" the mouse by means of radiation in wave lengths invisible to us — in other words, the infrared heat waves given off by the mouse. Although evidence suggests that owls are insensitive to infrared radiation, we could not ignore the possibility.

To test the heat, odor, and homing-on-sound hypotheses, we proposed to see whether WOL could find an object that had no smell and gave off heat no greater than the heat of the leaves on the floor, but which made sounds like a mouse rustling through the leaves.

A crumpled wad of paper (mouse-size), dragged through the leaves on a thread, seemed just right. We turned out the lights and dragged the paper wad through the leaves. We heard WOL leave his perch and strike. We snapped the lights on; he held the wad of paper in his talons.

Since the paper wad had neither smell nor heat (above the heat of its surroundings), we interpreted this test to mean that he could only have been using his ears to direct him to our fake mouse. Fortunately, since W. E. Curtis (1952) had shown that barn owls have no ability to echolocate, we could discount this possibility.

Theory suggests that an owl would need both ears to determine distance to a sound source, but we wanted to make sure. We plugged one of WOL's ears with cotton, turned out the lights, and released a mouse. We heard WOL leave his perch and strike in the leaves. We turned on the lights and saw both animals standing motionless, WOL about eighteen inches short of the mouse, but on the right line from his perch. We removed the plug and tried him again. This time, WOL caught it. We repeated this experiment with the cotton plug in WOL's other ear with the same result.

We now felt sure that WOL was using his hearing to guide him to the mice in the darkened room. L. R. Dice was the first to find that barn owls (and long-eared and barred owls, as well) could catch mice in total darkness. Dice's primary interest, in these experiments, was to determine the value of protective coloration in mice. To do this, he released two deer mice (*Peromyscus maniculatus*) of different color strains on the floor of a room in dim light. The color of one matched the background, and the color of the other contrasted with it. Dice then released an owl and recorded which mouse the owl caught. After many such trials, protective coloration was definitely shown to possess advantages for survival in mice.

Now, Dice used these species of owls as the predators in his experiments because he had previously found out just how much light these owls needed to see a mouse. Thus, he knew how much light

— Dr. William C. Dilger, Lab. of Ornithology, Cornell University


**Drawings show** (*left*) **outside and** (*right*) **inside parts of an owl's ear. Owls may possibly use flaps of skin in front of ears to change effective sound path to each ear and thus determine distance to sound source. An owl's eardrum is far larger, proportionately, than that of other birds, enabling an owl to hear less intense sounds. The columella is a large bone that takes the place of the hammer, anvil, and stirrup in mammals. In most birds, the columella is attached to the center of the eardrum. But in owls it's attached off-center. This probably gives the owl an advantage in hearing soft sounds. Other parts of specialized ear structure also seem designed for better hearing.**

each owl needed to see a mouse. Since he was interested in the visual selection of prey, Dice wanted to prevent the owls from catching mice by hearing alone. In order to do this, he made what he called a "jungle" — a lattice of sticks screwed together and held above the floor by uprights. The "jungle," he hoped, would keep the owls from catching the mice in total darkness, because the owls would not "dare" strike at them through this obstacle.

Dice felt that his "jungle" was also probably a closer approximation of natural conditions, where mice move about under shrubs and herbs, than a bare floor would be — a closer approximation of nature, because, when he had observed his owls catching mice on the bare floor, they had seemed to use their wings to enfold the mouse and pull it within reach of their talons. He assumed that the owls could not do this under natural conditions, because of the shrubs and herbs on the ground.

Our observations showed that WOL, striking his prey on the leaf-littered floor, held his wings over his back after he first struck. Only after he had caught and started to shift the mouse in his talons, did he lower his wings to the floor on both sides and "enfold" his prey. It appeared that WOL used his wings and tail as props when his talons were otherwise occupied and *not* to draw his prey within reach. WOL did this "enfolding" even when he struck a mouse near his feeding table, where table legs were in the way and his feathers became disarranged in the process.

The consistency of WOL's propping action led us to believe that such behavior occurs in nature, regardless of obstructions, and that the real effect of Dice's "jungle" had been to give painful consequences to the owls' more "natural" hunting method — by hearing — when they came up against the unnaturally rigid stick-lattice in total darkness.

In earlier experiments, testing the vision of owls with various levels of illumination, Dice had used dead mice as bait. They made no sound. He kept reducing the amount of light until the owls

— David G. Allen, Lab. of Ornithology, Cornell U.

SCREAMING BARN OWL displays large, strong beak. 'Face' is formed by feathers.

could no longer pounce on the dead mice. Then, by measuring that level of illumination, Dice knew how much light the owls needed to seize a mouse. He then measured the light available to night-hunting owls in nature and came to the conclusion that there must be many nights on which owls cannot see well enough to catch their prey.

What does all this mean? It means, first of all, that an owl, hunting by vision, goes hungry on cloudy, moonless nights, if he hunts his prey in the woods. Is it not possible that, under such circumstances, the owl will use his remarkable hearing to lead him to a mouse? It has often been suggested that owls use their ears to locate the general position of their prey and then switch over to using their eyes for the final strike. But WOL's ability to locate mice by hearing alone leads us to suggest just the reverse.

In our hypothesis, the owl's eyes would be used to avoid obstacles such as branches and twigs, while its ears would lead it to the final strike. Field observation supports this. Watch an owl hunting through the woods — he flies down from a branch, swoops low, and then rises to a perch. This pattern is repeated over and over again. Is he not perhaps getting close to the ground while he flies, in order to see branches as silhouetted against the relatively bright sky? On dark nights, he needs all the information his eyes can provide in order to avoid collisions with branches, while his hearing is valueless for this purpose. We do not mean to exclude the eyes completely from the owl's final "run in." Probably, in nature, owls use either ears or eyes, or both, according to the opportunity afforded. But from our work with WOL it seems clear that hearing alone will permit an owl to strike accurately in the dark.

*Roger S. Payne is now doing graduate work at Cornell University. Dr. Drury is director of the Massachusetts Audubon Society's Louise Ayer Hatheway School of Conservation Education.*

— Wes McKeown

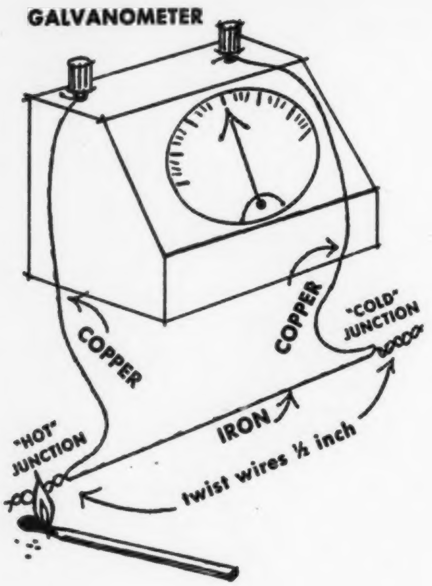



**Fig. 1: Heat can be converted directly into electricity by means of a thermocouple. To demonstrate this, connect an 8-inch length of No. 18 copper bell wire to each of the terminals of a galvanometer or a sensitive milliammeter, as shown. Connect the two free ends of the copper wires to the ends of a 6-inch length of iron wire (or wire made of any other metal except copper). Make the connection by twisting the ends to a length of ½ inch. (For your convenience, strip insulation from the wires.) Now hold a lighted match to one of the junctions of the iron and copper wires. Note reading on meter. Don't be disturbed if the current at first rises, then begins to fall off. This is characteristic of a copper-iron thermocouple. In fact, this particular couple will increase its thermoelectromotive force until it is heated to about 200° C. Then the electromotive force will decrease. At about 480° C., it will actually reverse its direction. Thermocouples made of other metal wires do not behave in this way. For example, one using wires of copper and of constantin (an alloy of copper and nickel) develops a considerable emf. It is the most commonly used thermocouple for converting heat directly into electricity.**

**A great deal of the energy used today to produce electricity is wasted. Much of this waste may be eliminated by exciting new developments in the field of**

# Changing heat

Ever since early man became civilized, he has searched for ways of making his work easier. First, he made animals do his work for him. Then, he developed crude machines and harnessed the power in falling water. Thousands of years later, he developed the steam engine, then electricity. For the first time in history, he could look forward to the time when he would no longer have to live a life of backbreaking drudgery.

Today, we have at our fingertips power undreamed of even a hundred years ago. But scientists in laboratories all over the world are continually on the lookout for ways of producing that power more efficiently and at less cost. The greatest source of electrical power today is heat. But most of the energy in the heat is lost in the process of changing it into electricity. The commonest sources of heat used in power generation are coal and oil, and we can't afford to waste either of them.

That's why thermionic conversion — the direct production of electricity from heat — looks so promising to scientists and engineers these days.

The conventional way of generating electricity is to boil water over a coal or oil furnace, using the steam to drive a turbine, and making the turbine drive an electric generator. The most modern steam power stations today are about 40 per cent efficient. This means that 40 per cent of the energy in the fuel winds up as electricity. Such stations are relatively costly, even though the cost to the user is only a few cents per kilowatt-hour.

— Westinghouse

PILE OF BLACK POWDER is ceramic material used in converting heat directly into electricity. In hand is same material in pellet form.

# into electricity

Anything that will simplify the process or make it more efficient will accomplish two important results: it will conserve fuel and reduce the cost of power. While keeping the cost down is important, conserving fuel is even more so. For, if our supplies of fuel were to be exhausted, the production of electricity would be limited to what we could produce from water power, from chemicals, and from still-expensive nuclear energy.

In an effort to produce electrical power more efficiently, scientists are exploring ways of converting heat directly into electricity. Man's first success in doing this came in 1826. In that year, the German physicist T. J. Seebeck discovered thermoelectricity. Seebeck took two wires, each made of a different metal, and joined them to make a circuit. (If you have a galvanometer or sensitive milliammeter you can rediscover the thermoelectric effect for yourself. For details, see Fig. 1.)

Seebeck's device became known as a thermocouple. It converts heat to electricity simply and silently. Why, then, isn't this device used to produce electrical power today? Because it has serious shortcomings. The entire action of the thermocouple depends on this fact: one of the junctions must be heated, while the other is kept cool. In general, the greater the difference in temperature between the two junctions, the greater can be the power delivered. This results in a problem. The wires used in a thermocouple

— G.E. Research Lab

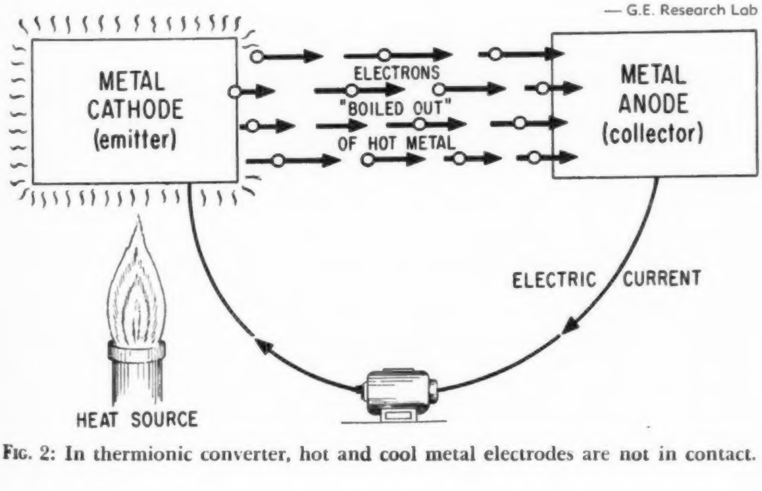



FIG. 2: In thermionic converter, hot and cool metal electrodes are not in contact.

— G.E. Research Lab
(adapted by Wes McKeown)

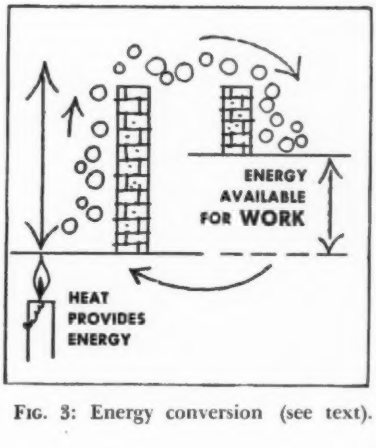
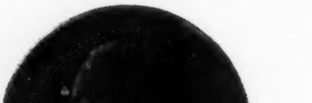



FIG. 3: Energy conversion (see text).

— G.E. Research Lab



Inventor James Beggs (*top*) heats thermionic converter. Device is same size as quarter (*bottom*).

are made of metals. Metals that conduct electricity are also good conductors of heat. So heat will be conducted from the hot to the cool junction.

Another shortcoming of the metallic thermocouple becomes evident if we use a Bunsen burner on the hot junction. The wires melt. Now, the efficiency in converting heat to electricity is high only if the temperature of the hot junction is high. The melting point of the metals, therefore, sets an upper limit to the thermocouple's efficiency. The efficiency of the metallic type of thermocouple is only 1 per cent. This means that only 1 per cent of the heat energy employed is converted into electricity. And that's why we haven't used the thermocouple principle to produce electrical power, even though we have long known about it.

How could the efficiency of a thermocouple be increased? It could be done in two ways: (1) by using a new thermoelectrically efficient material that would be able to withstand high temperatures but would not conduct heat; or (2) by separating the two junctions so that heat from one metal wire would not flow into the other, yet electrons would be able to move freely between them.

In one of those curious coincidences that have marked the history of science, two large research laboratories have announced, almost simultaneously, that they are well along the road to producing more efficient thermocouples. Westinghouse Research Laboratories are using the first method mentioned above. General Electric is pursuing the second. Let's look briefly at the work of each.

Westinghouse scientists have discovered a new "essentially unexplored class" of materials. These are ceramics, the broad group of substances that includes pottery and brick. (Technically speaking, the materials can be described as "mixed-valence compounds of the transition metals." The "transition metals" include iron, nickel, and manganese.)

Ordinary ceramics are able to withstand high temperatures, and they conduct little heat. But they do not conduct electricity. The Westinghouse ceramics have the first two characteristics but *do* conduct electricity. They can convert heat into electricity with promising efficiency at temperatures of from 2,000° to 3,000° F. At such high temperatures, they are inherently stable and chemically inactive. They can be heated indefinitely in air, without deterioration.

The Westinghouse ceramics have other things in their favor. The ingredients from which they are made are as common and as easy to obtain as those in a dinner plate. The chemical preparation of these ceramics does not require an extreme degree of purity. And their use raises no technological problems of high vacuum operation, of complex electrical or electronic apparatus, or the like.

In pursuing the second alternative, General Electric scientists have developed a "thermionic converter." This device has two metal electrodes that are comparable to the hot and cold junctions of a thermocouple. In a thermocouple, as we have seen, the two different metals (in the form of wires) are in contact with each other. But in GE's device, the electrodes are not in contact. They can therefore be held at different temperatures.

GE's thermionic converter produces a flow of electricity by "boiling" electrons out of a hot metal electrode. Electrons are the negatively charged particles that revolve around the nucleus of atoms. The atoms in this case are the atoms that make up the hot metal electrode. The electrons flow from the hot electrode (or emitter) to a cooler one (the collector). When electrons flow, the result is a current of electricity. (See Fig. 2.)

All metals have natural "barriers" at their surfaces. These barriers make it difficult for electrons to escape. Heating the emitter electrode makes the electrons more active. If the heat is great enough, the energy given them is great enough to "lift" some of them over the barrier of the metal so they can escape.

The electrode metals are carefully chosen. That of the emitter electrode has a greater barrier to the electron flow than that of the collector electrode. This is important to the successful operation of the device.

It's like making the electrons climb over two walls. The energy given the electrons as they escape from the emitter is partially lost as they "fall" over the collector wall (see Fig. 3). There is still some energy left, however. It is this energy that is conducted outside the converter to do work in the form of electricity.

Two kinds of thermionic converter have been built in the General Electric Research Laboratory. One, the invention of Dr. Volney

— G.E. Research Lab

## Meet the General Electric scientists

**James E. Beggs**

In addition to his work on thermionic converters, James E. Beggs helped develop miniature ceramic vacuum tubes. These have rivaled transistors in electronics circles.

Dr. Beggs was born in Omaha, Nebraska, in 1908. He grew up while radio was just getting its start. So it was natural for him to become an enthusiast in this field. Like many other youngsters, he built his own receiver and transmitter.

His interest carried over to college. He was graduated with a degree of B.S. in electrical engineering, went to GE in 1932.

Among his hobbies are landscape gardening, hiking, mountain climbing, and photography. He is married and is the father of three children.

**Volney C. Wilson**

Dr. Volney C. Wilson (at right, with *his* converter) is one of that select group of scientists who witnessed the first controlled release of atomic energy.

A native of Evanston, Illinois, he majored in physics and chemistry in college. He received his Ph.D. at the University of Chicago in 1938 and stayed on to do studies of cosmic rays. When World War II came, he was asked to work on radar development for the Government.

Early in 1942, he joined Enrico Fermi's famous group at the University of Chicago. These men achieved the long-dreamed-of release of atomic energy.

He joined General Electric in 1945. His hobbies are swimming and sailing. He is married and has two sons.

C. Wilson, is a tubelike device with a gas separating the electrodes inside. The other, invented by James E. Beggs, is a tiny gadget about the size of a quarter. Its internal electrodes operate in a vacuum. (Thermionic converters have also been built by scientists at the Radio Corporation of America, at Massachusetts Institute of Technology, and at Los Alamos Scientific Laboratory.)

The Wilson and Beggs converters are about 8 per cent efficient — that is, about 8 per cent of the heat applied to the electrodes is converted into electrical energy. Theoretical studies by another General Electric research scientist, Dr. John M. Houston, show that the efficiencies of such converters could reach 30 per cent or better. That's getting pretty close to the efficiency — about 40 per cent — of the turbine-generators in modern power plants.

There's good reason to expect, moreover, that thermionic converters could be combined with conventional turbine-generators in such a way that the over-all efficiency of the combined unit would reach new high values (see Fig. 4). Since the thermionic converter operates at a very high temperature, the furnace heat or the steam might first be applied to the converter to generate some electricity. Then the cooler steam could be used to drive the turbine-generator. It has been estimated that the over-all efficiency of such a converter-turbine-generator might run as high as 60 per cent or more. That would indeed be a revolutionary development in the electrical industry.

[*For more on thermoelectricity, see "Will It Work?" on page 21, at the end of our "Young Scientists" feature.*]

— G.E. Research Lab
(adapted by Wes McKeown)

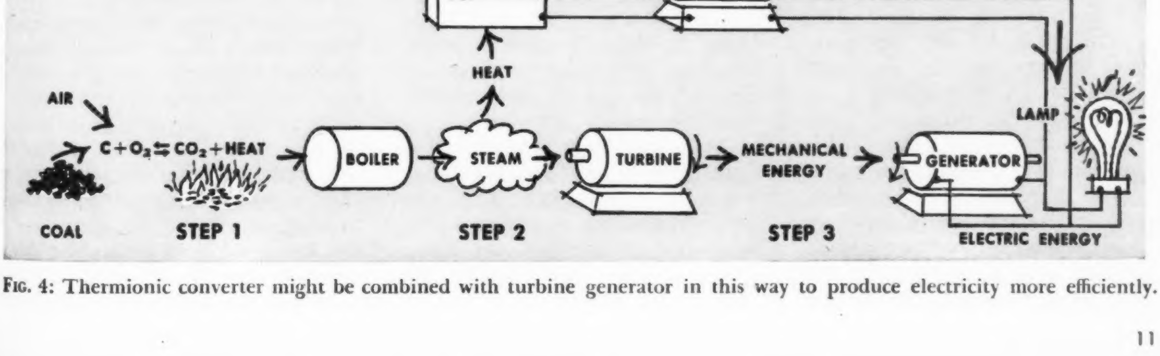



**Fig. 4:** Thermionic converter might be combined with turbine generator in this way to produce electricity more efficiently.

When experimental subjects were cut off from all sensory stimulation, they suffered hallucinations.

# GATEWAYS TO THE MIND

**Adapted by Edmund H. Harvey Jr. from the film script**

The reels on the tape recorder start to spin. The sounds coming from it could be fast native drums or somebody rapidly tapping his fingers. But they are neither. They are actually a recording of electrical impulses traveling from the eye to the brain. In other words, this is a recording of a person *seeing*.

This remarkable recording was made by Dr. H. K. Hartline of the Rockefeller Institute of Medical Research. He was investigating how the optic nerve carries information to the brain. His work is only one phase of science's current exploration of the human senses. Along with Dr. Hartline, countless other scientists are asking: What is a "sense"? How do the senses work? How many senses do we really have? What are their limits?

Some 2,200 years ago, the Greek philosopher Aristotle stated that man had five sense organs, which enabled him to see, hear, taste, touch, and smell. Since then our understanding of the human senses has come a long way; just how far is the subject of a new Bell Science Series film, "Gateways to the Mind."

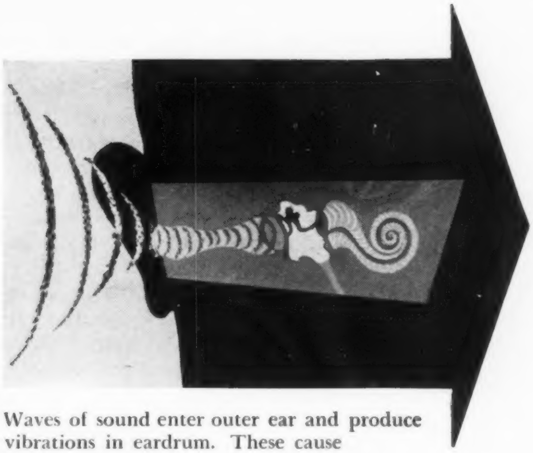
As the film points out, scientists now know that man has many more senses than the five recognized by Aristotle. "Gateways to the Mind" cites fourteen, but some scientists think man has literally dozens of true senses. A still more important discovery: we don't see with our eyes alone, or hear only with our ears. Our sense organs — eyes, ears, nose, tongue, skin, and the rest — do not create sensation themselves. Instead, each sense organ contains a special group of sensory receptors that, in response to certain outside stimuli, generate electrical impulses. Then, via the sensory nerve fibers, these impulses race to a specific area of the brain. There — and only there — do they become sensations.

One of Aristotle's basic assumptions, however, has never been challenged. "The whole world," he said, "comes to us through our senses." Now, as then, the senses are our only contacts with the outside world. Modern scientific instruments may be more powerful, more sensitive, and more accurate than ever before. But they are simply *extensions* of man's basic senses. (Imagine a blindfolded astronomer stepping up to look through a huge telescope.) Furthermore, the size and shape of every scientific instrument is strictly controlled by the position and capabilities of the human senses. For example, we just couldn't use a telescope designed for a grasshopper, a creature whose eyes almost cover his head.

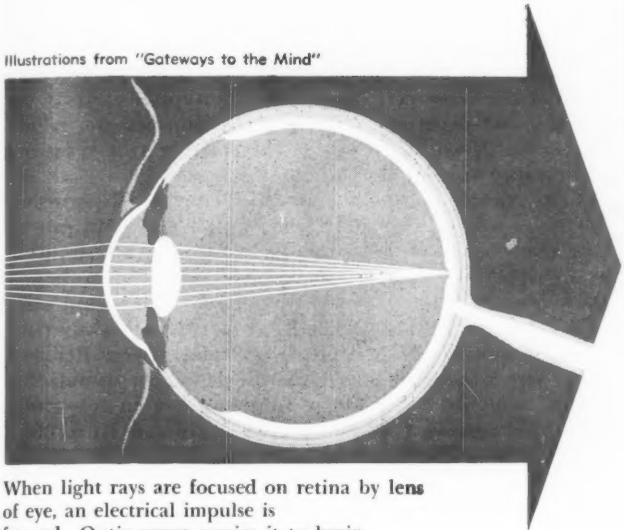
What are the senses that Aristotle overlooked?

Where Aristotle saw only one "sense of taste," modern scientists count four: sweet, salt, sour, and bitter. Similarly, Aristotle's "sense of touch" has been broken down into five senses: cold, heat, pressure, touch, and pain. The presence of two other senses, balance and muscle tension, has been definitely established. While smell and hearing are both still considered single senses, there is growing evidence that sight is a combination of at least two, and possibly five,

Illustrations from "Gateways to the Mind"



Waves of sound enter outer ear and produce vibrations in eardrum. These cause pressure changes in inner ear's fluid.



When light rays are focused on retina by lens of eye, an electrical impulse is formed. Optic nerve carries it to brain.

senses. Some scientists think tickling — that is, being ticklish — represents another true sense.

Modern scientists aren't just splitting hairs when they divide taste into four separate senses and touch into five. Each of these newly identified senses has its own unique set of sensory receptors. We could no more taste a sweet substance with our sour receptors — or feel cold through our touch receptors — than we could smell with our ears.

The eye seems to have two types of receptors. One responds to colors, another to black and white. On the retina of the eye are more than 125 million light-sensitive cells. Apparently, these are divided into two distinct kinds, called rods and cones. In bright light, the cones react to colors. But in dim light, the cones stop functioning, and the rods take over. Rods react only to dark and light — black and white — stimuli. That's why we can't see colors at night.

Both rods and cones have a special pigment at their tips. When light strikes the tips, it momentarily bleaches them. This sudden change from color to colorlessness releases a tiny charge of electrical energy which excites an adjoining nerve cell. This nerve cell then passes the electrical impulse on to the next nerve cell, and so on, until the impulse reaches the brain. Meanwhile, the pigment at the tips of the rods and cones has renewed itself and is ready for the next stimulus.

As in the eye, all our sensory receptors react to some special kind of stimulus, producing in the process a charge of electricity. In the case of smell and the four senses of taste, the stimulation is chemical. Smell is the result of volatile molecules reacting chemically with some of the millions of receptors in the olfactory patch of the nose. Taste receptors react to the chemicals in food and drink. Hearing depends on some 24,000 hairlike receptors within the fluid of the inner ear. Sound waves striking the eardrum are transformed into corresponding pressure waves in the inner ear fluid. These pressure waves then hit a particular group of hair cells, which electrically activate adjoining nerve cells. In split seconds, impulses are on their way to the brain.

Many of our sensations are produced by two or more senses working in unison. Flavor, for example, is produced by both smell receptors and taste receptors. Very few foods stimulate only our taste receptors. The tongue's touch receptors also figure in our reaction to food, telling us whether it is hot or cold, smooth or crunchy. In keeping our balance, we use not only our sense of balance but our sense of muscle tension and, more often than not, our eyesight.

Every sensory receptor is connected to a nerve cell that is part of a whole network of nerve fibers. Through this network move the electrical impulses that originate at the senses. Jumping from nerve cell to nerve cell at more than 100 miles per hour, the impulses converge at the thalamus, a kind of electrical relay center at the base of

the brain, and are then directed upward to the grey outer layer of the brain called the cortex. Not until the impulse reaches the brain can we experience sensation or act on the information our senses have received.

There is one important exception: pain. We react to pain *before* the pain impulse reaches the brain, before we even know we're hurt. What happens is this: in our bodies, particularly along the spinal cord, we have several nerve "reflex centers." When the pain impulse reaches one of these, it triggers an immediate reflex action, then goes on to the thalamus. Pain receptors are simply free nerve endings located throughout the body.

One surprising fact about the electrical impulses from the senses is that they are all the same, no matter what sense they come from. One sense's "signal" is no different from another's. Of course, the *number* of impulses from a particular sensory receptor does vary, depending on the amount of outside stimuli. But Dr. Hartline's recording of the electrical impulses of seeing could just as well be a recording of someone listening to music . . . or eating a sour ball.

It's the *area* of the brain the impulses reach that makes the difference. Each sense's impulses have their own special destination in the brain. When impulses arrive at the "bitter taste" part of the brain, we become aware of a bitter taste on our tongues.

The brain does more than just sort out sense impulses. It also checks them against past experience. For example, suppose you were eating an apple and suddenly got a strong bitter taste. Your brain would check this against past experience and find that apples should be sweet. Bitter is suspect. Very possibly the apple is wormy. You throw it away.

One of the most startling scientific discoveries of recent years concerned the human brain's ability to retain past sensations and experiences. Dr. Wilder Penfield, world-famous Montreal brain surgeon, presented undeniable proof that man's brain contains a record of all the sensations that have ever been stimulated in him by the external world. Each new sensation, scientists assume, is referred to this "memory bank" for approval. If it resembles certain past sensations in similar situations — if, for example, a sweet sensation arrives at the brain when a person is eating candy — then the sensation is approved. But if the sensation is unexpected or irregular, then the brain is alerted and suspicious.

During several brain operations, Dr. Penfield applied an electrode to the temporal lobe of his patient's brain. In effect, he was using a substitute for the electrical impulse that would naturally come from the patient's senses. Under local anesthetic, and fully conscious, one patient saw a baseball game. Another heard a song. Another saw "a railroad station in a small town in Kentucky." A fourth: "Children's voices. I hear them, down along the river." Depending on the precise point of the temporal lobe touched, each patient would call up long-forgotten sensations and experiences, and "hear" or "see" them just as vividly as he had many years before.

Besides proving the existence of a "memory bank," Dr. Penfield's experiments emphasized, once again, the brain's active and critical role in sensory perception. Also, the experiments performed the fantastic feat of creating true sensation without the senses.

But Dr. Penfield's experiments don't mean that the brain can do without the senses. Far from it. Striking evidence of the brain's need for sensory stimulation came recently from McGill University. Student volunteers were deprived of virtually all sensory stimulation. They were swathed in soft cloths and placed motionless on comfortable beds in tiny, dimly lighted, soundproof rooms. None could stick it out longer than forty-eight hours. Each, with his mind no longer receiving its usual quota of sense impulses, began to have hallucinations.

The McGill experiment sheds new light on why truck drivers on long, monotonous hauls or jet pilots droning along in the stratosphere experience frightening and dangerous hallucinations. And it anticipates a big problem of future space travel: how will space explorers get the sensory stimulation their brains will need?

Everything modern science has learned about the senses has emphasized the mutual dependence of the brain and the senses. They complement each other in a kind of symbiotic relationship: the brain gives relevance and meaning to the senses; the senses give the brain the stimulation it needs to function properly. Out of this relationship comes, quite literally, all we know, do, and think.

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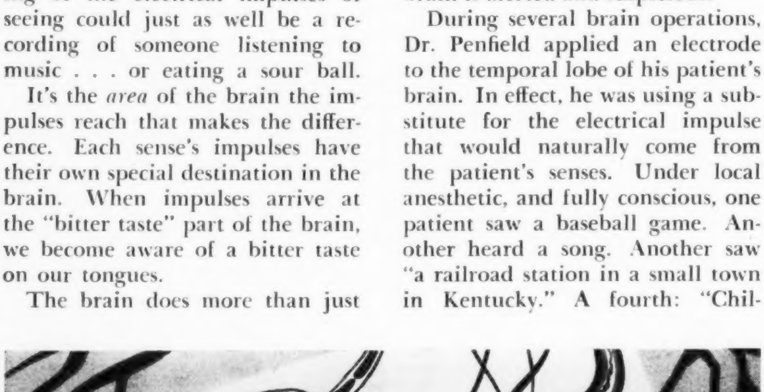
*This article was drawn from the script for the new Bell System Science Series program, "Gateways to the Mind." It will be telecast over the NBC network Thursday evening, October 23. Check your local TV listings for the time this program will be seen in your section of the country.*




**In finger tip,** man has five separate sense receptors for experiencing sensations.

## Progress report on IGY
**part II**

# Probing the secrets of space

**By Fredric C. Appel**

The human race is like a species of deep-sea fish that lives at the very bottom of a great ocean. But the ocean of man is made up of air rather than water. We know practically nothing about the upper regions of our ocean, which we call the atmosphere. And we know even less about what lies beyond it.

One of the main purposes of IGY has been to learn more about the great unexplored areas of the atmosphere and about interplanetary space. As a result of history's greatest scientific effort, we are now discovering partial or complete answers to many questions, some of which were first asked thousands of years ago. A few of the more important questions and their answers follow.

**How far does the earth's atmosphere extend?**

A few years ago, scientists generally believed that our blanket of air extended about 600 miles from the earth. Later evidence indicated that it might extend a great deal farther.

To check on this and other questions, IGY scientists have been probing high into the atmosphere with balloons and research rockets, even higher with man-made satellites. Their findings confirm the evidence that the atmosphere ends much farther than 600 miles out. In fact, some findings suggest that it may not end at all. Instead, it may stretch outward until it finally merges with an invisible outer atmosphere of the sun.

Of course, the atmosphere does thin out rapidly as altitude increases. It is so thin where the satellites are orbiting, hundreds of miles above the earth, that they encounter practically no air resistance. Scientists have calculated that if all the atmosphere were compressed to the air pressure at sea level, it would be only five miles high. To look at it in another way, a full nine-tenths of all the air in the atmosphere is contained in the first ten miles above the earth's surface.

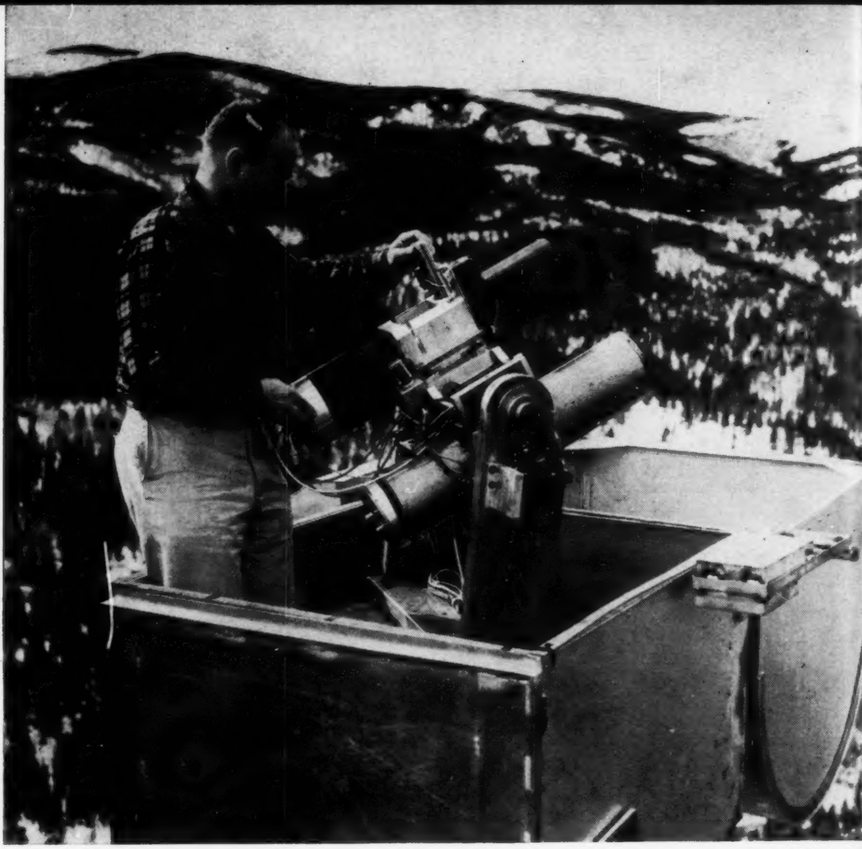
**What causes the northern lights?**

Near the North Pole, flickering curtains of light occasionally dance across the night sky. These are the northern lights, or aurora borealis. Similar lights (aurora australis) show up near the South Pole.

Scientists have long been intrigued by these auroras. They've suspected that the lights are caused by streams of radiation coming from the sun. During IGY, scientists have pretty well proved this to be so.

Researchers stationed at both poles have been photographing the auroras with all-sky cameras. The all-sky camera was developed especially for IGY. It uses a convex mirror to photograph the entire sky from one horizon to another.

One of the first facts learned by polar researchers was that the aurora borealis and aurora australis tend to occur simultaneously. When an aurora appears over the North Pole, there is usually one over the South Pole. This proves that auroras are not caused by some local condition at either pole. It helps support the belief that auroras are caused by radiation.



Electronics scientist C. M. Purdy adjusts photoelectric photometer, used to measure intensity of airglow, weak light in night sky usually not visible to naked eye.

— Nat'l Academy of Sciences, IGY photo

Seeking a connection between radiation and auroras, the scientists placed various radiation-detecting devices at each pole. These showed that whenever auroras appeared there was a great increase in radiation. Moreover, the increased radiation was directly related to a stepping-up in the sun's activity.

The sun, our parent star, exhibits a number of strange phenomena on its surface. Dark spots, called "sunspots," appear at various times. Near the sunspots, explosions occur. These are solar flares. The flares are actually ejections of very hot gases from the sun's surface.

IGY scientists have noted that large flares on the sun are usually accompanied by extensive auroral displays. Apparently, a flare shoots out radiation in the form of tiny charged particles. These particles bombard the earth's atmosphere and excite atoms and molecules there. The result is the light of the aurora.

**Why do auroras usually occur only at the poles?**

As we have seen, auroras are caused by charged particles. Charged particles are affected by magnets. Now, we know that the whole earth is a huge magnet. The poles of this great magnet are near the geographic North and South Poles. When charged particles approach the earth, many are pulled toward the poles by magnetic attraction. For this reason, the shower of aurora-causing particles is strongest at the poles.

**Where do cosmic rays come from?**

Cosmic rays also consist of charged particles that rain down on the earth's atmosphere. They are similar to the radiation that causes auroras. But they travel at far greater speeds and pack thousands of times as much energy.

Cosmic rays are deadly to living things. Fortunately, our atmosphere shields us from them. But they do pose a great problem to human space travelers.

There have been many theories about the origin of cosmic rays. Some scientists thought they came from the sun. Others suspected some unknown source among the stars. At one point in his career, Dr. Albert Einstein suggested that cosmic rays might be rays of energy that had reached the limits of the universe and were returning on the curve of space. IGY scientists have been studying these theories.

On rare occasions, they say, the sun produces short bursts of charged particles with cosmic-ray energy. But most of the cosmic rays that reach our atmosphere come from elsewhere in our vast galaxy, the Milky Way. Exactly where they come from and how they get their tremendous energy are still questions that puzzle scientists.

IGY studies have revealed an interesting fact about cosmic rays. They usually *decrease* when solar activity increases. The explanation: Eruptions on the sun send out great bursts of highly charged gas. Electric currents flow through these gas clouds, and magnetic fields are set up. When cosmic rays heading toward the earth hit such a magnetic field, some are deflected in a direction away from the earth.

**Have the dangers of space travel been exaggerated?**

No. In fact, there is a possibility that the dangers have been underestimated.

It's not enough to design a rocket that can carry man into space. Scientists must know the dangers he faces so they can devise methods of protecting him from these dangers. The satellites launched during IGY have thrown light on some of these hazards.

One of the most important satellite studies concerns the small pieces of metallic material that shoot through space. These are commonly called micrometeorites or meteoric debris. Most of the pieces of this debris are the size of fine grains of dust. A few are birdshot size or larger. How much damage could this material do to a space vehicle?

The first satellite launched by the U.S., Explorer I, took the measure of the micrometeorites, found them few and far between. A Russian Sputnik confirmed this finding. But later satellites have told a different story. Some have apparently been damaged by meteoric debris. Though estimates of the amount of meteoric debris vary, it may present a real hazard to space travel.

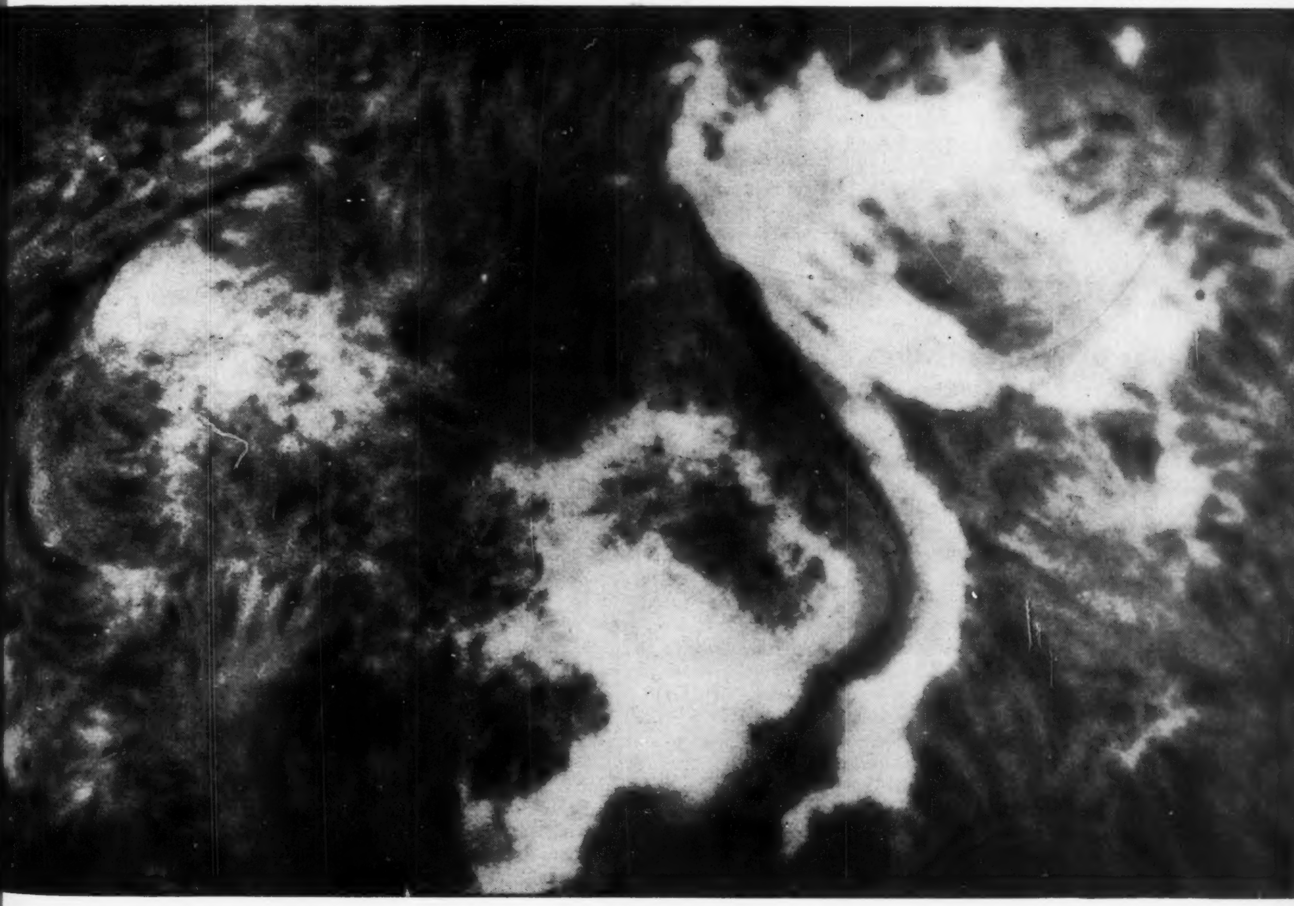
Another hazard was discovered by a U.S. Explorer satellite: a band of very intense radiation at the outer fringe of the earth's atmosphere. The radiation was so intense that it completely saturated the radiation counter in the satellite. Scientists were able to estimate its intensity by seeing how much radiation it took to saturate similar counters in the laboratory.

Space scientists are still discussing just how dangerous this band of radiation is and how much shielding will be necessary to protect a space traveler from it. There's no doubt that this radiation further complicates the problems of space travel. One scientist, however, estimates that the band is only about 40,000 miles in width. If so, a rocket ship could pass through it fast enough so that the passengers wouldn't receive a fatal radiation dose. But recent reports from Explorer IV suggest that the radiation is even stronger than originally thought — and thus poses a greater peril.

Much of the information gained from IGY research in the upper atmosphere and in space is not entirely new to scientists. In many cases, they correctly predicted the results. But IGY is furnishing factual support to many theories and providing exact figures to replace previous estimates. Our scientists and engineers need these facts and figures to design spaceships and other devices for our future.

ACTIVE PART of the sun's surface, as photographed by scientists during IGY.

— Nat'l Academy of Sciences



# Science in the news

## Balloon will hunt for 'untamed' cosmic rays

Where do cosmic rays come from? What is the nature of these tiny particles before they collide with atomic fragments in the earth's atmosphere and explode? This winter, physicists at the University of Chicago will send up the world's largest balloon in an attempt to find out. (For more on cosmic rays, see IGY report on page 15.)

Up 25 miles from the earth's surface, in the middle stratosphere, cameras in the balloon will photograph the rays. There, the rays move with energies a thousand times greater than any yet produced by man. The film may also show the split-second explosions created when cosmic rays are stopped by the earth's atmosphere.

The giant unmanned balloon will be launched from somewhere along the earth's magnetic equator – the imaginary line where the lines of force of the earth's magnetic field are parallel to the ground. Only the most powerful cosmic rays can pierce this magnetic fortress; weaker rays are turned away.

Buoyed by helium, the balloon should stay aloft for a record twenty-four to forty-eight hours, the physicists say. The launching will begin a three-year project financed by the National Science Foundation and carried out by the University of Chicago and the Office of Naval Research.

## Space plan, ocean study set up by scientists

Though IGY ends this December, the world's scientists will continue to pool their "know-how" in a number of areas. Two of the most important of these are space exploration and oceanic research. The scientists made the decision this month at a meeting of the International Council of Scientific Unions, held in Washington, D. C.

A committee on space research, called COSPAR, will be formed. This will be a non-political body set up to co-ordinate research in outer space by all nations. The committee will have fifteen months in which to work out a long-term plan. It is hoped that this plan will eventually lead to a permanent organization – a "United Nations of Science."

A four-million-dollar research study of the Indian Ocean is also being planned by the scientists. It may grow into the greatest single oceanographic research effort in history. To begin in 1961, the project calls for 125 scientists using research ships from eleven countries. Problems to be tackled include: the mysterious mass deaths of fish in the Arabian Sea (a part of the Indian Ocean lying between Arabia and India); the effects of the monsoon winds on the Indian Ocean; and a survey of that ocean's little-known floor. In addition, many of the ocean studies being carried out during IGY will be continued.

Both projects will be patterned after the IGY program. This program has been very successful in enabling the world's scientists to work together unhampered by political and military considerations. The Council is sponsoring IGY.

## Moon to be unspoiled by lunar probes

The moon will be treated gently in U. S. lunar probes. Lunar vehicles will not only be sterilized but will be aimed so as to avoid impact with that body. Our Government has agreed to follow these and other rules set up to prevent the moon's "contamination."

The moon could be contaminated by foreign matter brought from the earth by a lunar rocket. Then, in later studies, scientists wouldn't know whether the matter they found originated on the moon or on the earth.

The moon-flight rules stem from the broad program of space-research control under study by the International Council of Scientific Unions. They were prepared by the Committee on Contamination of Extra-Territorial Exploration – better known as CETEX. Here are some of the rules:

- Nuclear blasts on the moon's surface are to be delayed. Such explosions would produce radioactivity. This would interfere with studies of the moon's origins by such methods as analyzing the radioactivity of lunar rocks. Big TNT blasts are also to be avoided, since they could contaminate the moon for a number of years.
- "Soft" landings of vehicles on the moon are banned until a thorough study has been made of the moon's atmosphere with low-flying satellites. Scientists would be unable to determine the nature of the thin lunar "air" if it were contaminated by the burning of the tons of fuel needed to brake a rocket for a gentle landing.
- Any "hard" (crash) landings are to be limited to as small an area as possible. Otherwise, the moon's surface would be extensively contaminated by the large molecules produced by life on earth.

## Off-course moon shot still acclaimed a success

The place was Cape Canaveral, Florida. The date: Saturday, October 11, 1958. The time: 3:42 A.M. (EST). An Air Force scientist pressed a button and a ball of searing white light rose from the launching pad. Pioneer, the second U.S. moon-probe rocket, was on its way.

A few minutes later, the Air Force announced that all three main stages had fired successfully. But the first-stage Thor had risen at a sharper angle than planned. The cause: an error in the automatic pilot.

Slowed by the change in trajectory, Pioneer did not gain sufficient velocity to reach the moon, some 220,000 miles out in space. Instead, it reached a peak altitude of 69,000 miles 27 hours after launching, then began to fall back toward earth. On Monday morning, October 13, it re-entered the earth's atmosphere and burned up.

Even so, Pioneer was acclaimed a tremendous success by scientists the world over, for it accomplished a number of important objectives and far surpassed the reach of any other man-made object into space.

First, Pioneer's three main stages—including the third-stage untried solid-propellant rocket—fired perfectly and in proper sequence.

Second, Pioneer's velocity fell short by only a few hundred miles per hour of the 23,870-mph goal.

Third, Pioneer was gathering data in parts of space never before explored. Previous satellite and rocket records were 2,500 and 4,500 miles from earth respectively. Pioneer reached 69,000 miles into space. Information pouring into a worldwide network of ground stations from the instruments in its fourth-stage payload included data on the magnetic field of earth, micrometeorites, and zones of radiation that would be dangerous to man in space.

Hopes are high for the next moon shot, perhaps a month from now. For Pioneer has proved that man can send a rocket to the moon—and soon will.

## Radioactive material damages human bone

The menace of strontium 90 to human health has been spelled out in more detail by scientists. Strontium 90 is considered the most dangerous product of radioactive fall-out from nuclear explosions. Carried around the world by air currents, it settles on vegetables and other plants. It is taken into the body with food. There, it finds its way into bone.

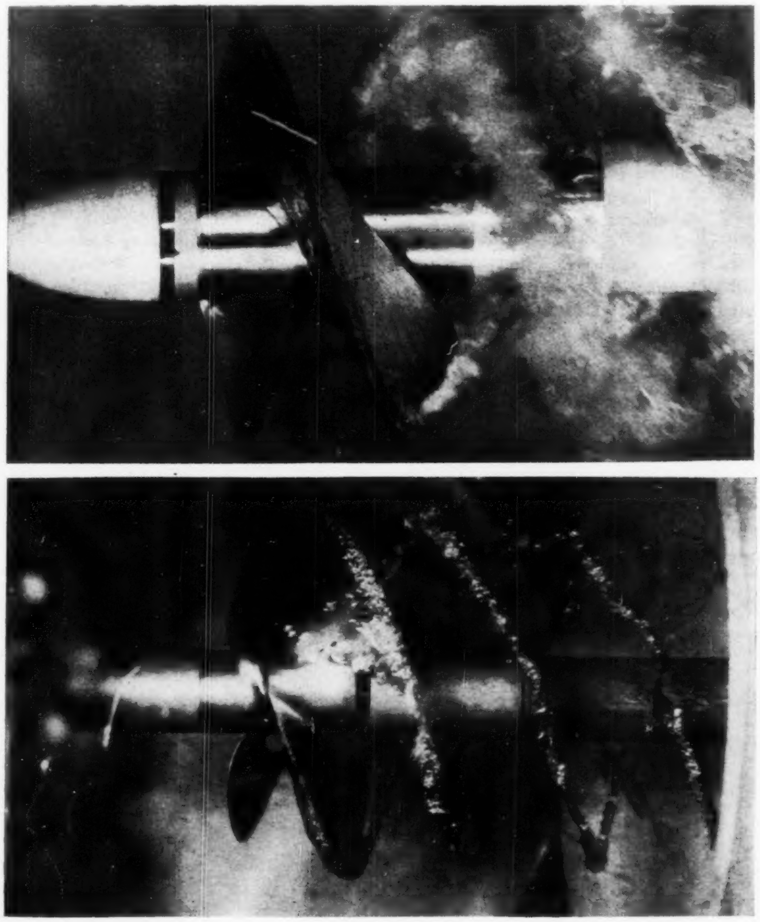
Since nuclear explosions are a fairly recent development, the precise effects of strontium 90 may not be known for years. But scientists at Argonne National Laboratory in Lemont, Illinois, have determined some of its probable effects.

The scientists studied fifteen persons who have radium in their bones. The radium came from industrial and medical exposure. Since strontium 90 and radium are both radioactive bone-seekers, it is probable that they have similar effects.

The scientists found that when radium was present the blood-carrying canals of the bones became clogged. Small portions of bone died. (Since bone is a living tissue, it must have a continuous blood supply.) Normally, dead bone is removed from the body in the course of time. But in this case the lifeless bone remained. This probably accounts for bone-structure changes, such as brittleness, observed in the fifteen persons. It was also found that the radium had remained in their bones for twenty or more years.

Conclusion: once it gets into human bone, strontium 90 will remain there and cause damaging structural changes.

—Official photograph, U.S. Navy



**Supercavitating** is what the Navy calls new ship propeller *(top)*. It may revolutionize shipping as jet did aviation. Propeller is shaped like the screw part of an ordinary kitchen food grinder. Speed of conventional propeller *(bottom)* is limited by cavitation – vapor pockets that form around it. Shape of new propeller actually capitalizes on vapor pockets, thereby increasing speed and efficiency.

# News in brief

● A Lockheed X-7 ramjet now holds the record as the fastest air-breathing missile in the free world. The X-7 flew at more than four times the speed of sound. The missile's altitude was kept secret, but the Air Force did say that the missile soared to the edge of the upper atmosphere. So much heat was generated by friction with the air that part of the missile burned away.

● A bow and arrow recently solved an atomic-age problem. Scientists at Los Alamos Scientific Laboratory in New Mexico had to string wires across a canyon to furnish electricity for advanced research. The chasm was too steep to climb and too wide to be bridged by a hand-thrown line. A lab employee, handy with bow and arrow, provided the solution. He tied some fishing line to the tail of an arrow and shot the line across the canyon. After that, it was easy to string wires to the other side.

● Future spacemen may need ear surgery. At least one, and possibly two, organs of the inner ear may have to be put out of commission to prevent a distressing type of motion sickness in space flight. One of the organs aids body balance, the other helps man judge "which way is up." According to a Navy space-medicine expert, the organs involved are largely vestigial.

● A sure cure for fading flamingos seems to have been found. Zoos have long been plagued by the fact that the big birds' color fades after they are in captivity. Recently, the staff of the Bronx Zoo in New York experimented with diet in an effort to bring back the splendor of their flamingo flock. The birds were first fed shrimp and lobster. This yielded only feeble results and proved expensive. Then they were given carrot extract. Within months, the birds turned from pinkish-white to yellowish-red. Next year, their color will be even more brilliant, predicts the Zoo's curator of birds.

● Scientists at Columbia University may have hit upon a way to detect nuclear explosions set off anywhere in the world. They have developed a "long-period" seismograph that records shock waves with an interval of a minute or more. This means that the earth's tremors now can be heard from greater distances than ever before. A standard seismograph can only record shock waves at a frequency range of one to twenty per minute. The new device has already recorded nuclear blasts set off more than 7,000 miles away.

# PROJECT SELF-STARTERS

## A reaction timer

How long does it take for a person to react to a visual or auditory stimulus? How widely do people differ in their reaction times? Do you react faster with your hand or with your foot? What effect has practice on reaction time?

These are the kinds of questions that you can answer with data obtained with a simple, homemade reaction timer.

Briefly, the principle of the reaction timer is this: A voltmeter is connected to a battery in a circuit containing two switches and a bulb, as shown in Fig. 1. Each of the switches is of the momentary contact type. One is normally open but, when pressed, closes the circuit (as a doorbell push button does). The other is normally closed but, when pressed, opens the circuit (as a refrigerator light switch does).

The experimenter has the normally open switch in his hand, while the subject holds the normally closed switch. The subject is told to press his switch as soon as he sees the light go on.

When the experimenter closes and holds down his switch, the light goes on and the meter needle begins to move up the scale. The subject, on seeing the light, immediately pushes and holds his switch. The light goes out, and the meter needle stops moving up the scale and falls back to zero. By noting the highest point on the scale that the needle has reached, the experimenter has a measure of the relative time it takes for the subject to see a light and push a switch.

In the suggested layout of parts shown in Fig. 1, the voltmeter is a 0- to 3-volt instrument. The bulb is a standard 3-volt flashlight bulb. The two switches, as mentioned earlier, are the momentary contact type, one normally closed, the other normally open. They can be obtained from any radio-supply house. Power is furnished by two flashlight cells wired together in series. Contacts to the cells can be made by soldering the wires directly to the cells.

An improvement can be made if a milliammeter is used and an appropriate resistor (a 1,000-ohm variable resistor will usually do) is wired in series. The resistor should be adjusted to give a full-scale deflection of the needle when the experimenter's switch is closed.

When operating the reaction timer, the experimenter should be behind the subject, so that the subject does not see and react to the pushing of the switch by the experimenter. The subject should be instructed to watch the light and push his switch as soon as it goes on. The experimenter should concentrate on watching the meter needle and noting the highest point on the scale to which it rises.

Variations of the experiment can be made. If the subject's switch is mounted so that it can be operated by foot, experiments can be performed to show eye-foot reaction time. By substituting a buzzer for the light, the time reaction to an auditory stimulus can be ascertained. Many comparative studies can be made. Examples: the reaction time of an old person and a young person; a boy and a girl; the reaction time of an individual in the morning and the evening, before and after sleep, before and after a meal.

## Culturing fruit flies

The fruit fly (*Drosophila*) is an ideal organism for the study of heredity and variation. It can be readily cultured at home or in the laboratory.

To prepare a simple "kitchen made" culture medium, measure out 77.5 cc. of water, 11.5 cc. of Karo syrup, and

— Gloria LoCurcio

Fig. 1

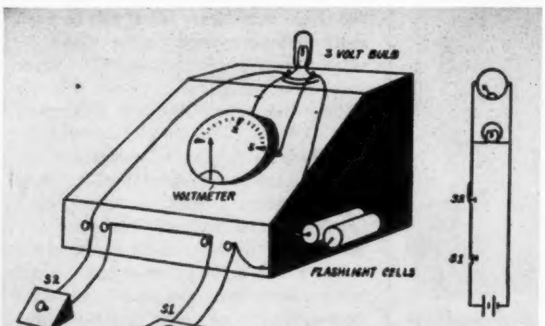
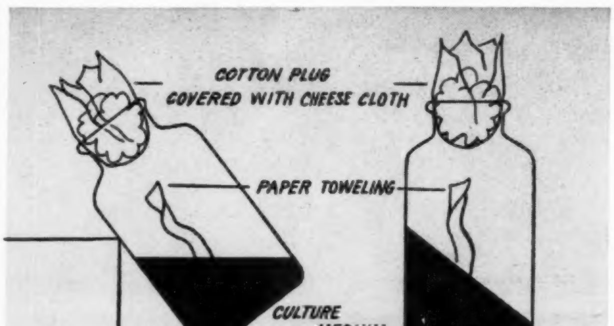



Fig. 2



**Here are several ideas, each of which can develop into a wide variety of projects and club activities. Try them, and think about them. You will find that each invites further exploration and experimentation.**

10.3 grams of Cream of Wheat. Add the syrup to two-thirds of the water and bring to a boil. Mix the Cream of Wheat with the remaining one-third of cold water and add this to the boiling mixture. Continue to stir, and cook for five minutes after boiling begins. Pour the medium into half-pint milk bottles, which have been previously sterilized. About an inch of medium in each bottle will do. Then insert a strip of paper toweling into the medium to provide a place for pupation. Tilt the bottles against a ledge to increase the surface area, and allow the medium to cool. Plug with cotton wrapped in cheesecloth or milk-bottle caps. A completed bottle looks like the one at right in Fig. 2. After the medium has cooled, add one drop of yeast emulsion in water.

Pure stocks of *Drosophila* may be obtained from a scientific supply house or a college laboratory. The wild variety can be found around soft grapes, plums, bananas, or any fermenting fruit. These flies have a two-week life span.

The culture can be started with a single pair of flies. Remove parents after ten days. Young flies will emerge after the twelfth day and should be examined and counted thereafter for ten days. To examine the flies, place an empty bottle over the mouth of the culture bottle, and surround the culture bottle with dark paper. Since the flies are phototropic (move toward the light), they will go into the second bottle. When they do, quickly separate the bottles and stopper the second bottle with a plug containing a small amount of ether. Avoid excess ether, for it will kill the flies. (When wings stand out at an angle, flies are dead.) The etherized flies can then be spilled out on white paper for examination.

## A chemical clock

You mix together two clear solutions. The mixture is clear for 15 seconds and then, with a startling suddenness, the solution turns a deep blue color. This is a chemical time reaction — a chemical clock whose timing you can accurately predict, if you know the temperatures and amounts of each solution.

The materials required are: sodium sulphite, starch, sulfuric acid, and potassium iodate. To make the first solution, dissolve 10.7 grams of potassium iodate in a liter of water. Prepare the second solution in three steps. First, place 8 grams of starch in a small beaker and add a small amount of cold water. Mix the starch and water to form a suspension. Then stir the mixture into a large beaker containing 100 cc. of boiling water. While the starch paste is cooling, dissolve 3.15 grams of sodium sulphite in a small amount of water in a liter container. Add the starch paste to the sulphite solution. In a beaker, dilute 5½ cc. of sulfuric acid with 100 cc. of water. (*Caution: always add the acid to the water.*) Pour this into the sulphite and starch solution. Now add enough cold water to make the resulting volume one liter.

Start the experiment by stirring together 100 cc. of each of the two solutions. Stir the mixture quickly, and note the time in seconds that it takes for the blue color to appear. Now, vary the proportions of each. Try 160 cc. of the sulphite solution with 40 cc. of the iodate. Also, experiment to show the effect of temperature upon the speed of reaction.

This chemical time reaction depends on a two-step situation. The last reaction, which causes the color, cannot proceed until the first reaction has gone to completion.

# WILL IT WORK?

Suppose we build a thermoelectrically operated electromagnet. As shown, it consists of a single turn of very heavy copper wire — about as thick as your finger. Between the two ends of the coil, we fasten a piece of constantin metal — an alloy that is a good electrical conductor. When used with copper, constantin generates a relatively high thermoelectromotive force. Now, suppose we heat one junction of the copper-constantin thermocouple and are able to hold a 200° C. difference between the hot and cold junctions. This will result in the production of an emf of about 5 millivolts. The resistance of the thick copper wire is low — about 1/100,000 of an ohm.

Applying Ohm's Law, $I = V/R$, we find that the current flowing through the loop is about 500 amperes. We know that the strength of an electromagnet depends, among other things, on the current flowing in the coil. Therefore, would not our single loop, provided with a good iron core, be able to produce a strong magnetic field and lift heavy objects?

Give the problem some thought. When you have reached a conclusion as to whether such an electromagnet would work, turn to page 30 for the answer.

Careers

# The researcher as a man

**Jerry Probst is a biochemist whose main job is to look for drugs of use in fighting cancer. He is a member of the Eli Lilly research team, which includes hundreds of scientists. But at the same time he is very much an individual. This story describes his work and some of his feelings about it**

Jerry Probst had been in his laboratory only a few minutes when he fumbled for the ringing telephone. He held it, balanced precariously, to his ear for a moment, then blurted, "Just a second, Dick. I've got a handful of bottles." After the short phone talk, he set off down the hallway toward a distant laboratory, on his way for a quick look at experimental mice being treated with an unknown anti-cancer substance.

Dr. Probst's own laboratory is a room about twenty feet square, lined on one side with shelves of multi-sized bottles of chemicals, some filled and others in various stages of depletion. In other areas of the lab are workbenches, apparatus, desks, and files. There to assist Dr. Probst are his associates, Gail Pittenger and Harry Martlage.

## On the run

On his return trip up the hallway, Dr. Probst paused to ask another researcher about an experiment, stopped off in a neighboring lab to check the progress of a cancer-screening run, and re-entered his own area barely ahead of a visitor who was bringing him sheets of data.

This briskness was to continue most of the day, and Dr. Probst had to be collared between interruptions for this story of how he feels about his work.

He described his job as consisting mainly of a search for anti-cancer chemicals and substances from fermentation broths. It is a job that could be a very long time producing the kind of results he is looking for. "But," he said, "I do think cures for cancer can be found — otherwise I couldn't continue with this work.

"Here's how things sometimes happen," he said. "Some years ago, we had a fermentation broth that repeatedly retarded the growth of mouse cancers. We were just beginning to find out something about the part of the broth that was actually producing these effects when suddenly its power to destroy tumors disappeared. For some unknown reason, the microorganism producing the broth in a fermentation tank, probably through some quirk in its life processes, put an end to the promising substance. For nearly a year, our microbiologists used all their facilities and knowledge attempting to reproduce the stuff, whatever it was. To date, they haven't found a trace of it.

"Modern science still has much to learn about the fundamental life processes it is working with. We at Lilly screen thousands of substances, then run further tests on the promising ones — trying to identify them, trying to understand them, trying not to lose them, trying to make them work, first in animals and then in humans. We very rarely reach the point of even considering a test in humans."

Asked how he became involved in such work, Dr. Probst said that it all began when he was a child in Morris, Minnesota, where he was born 35 years ago.

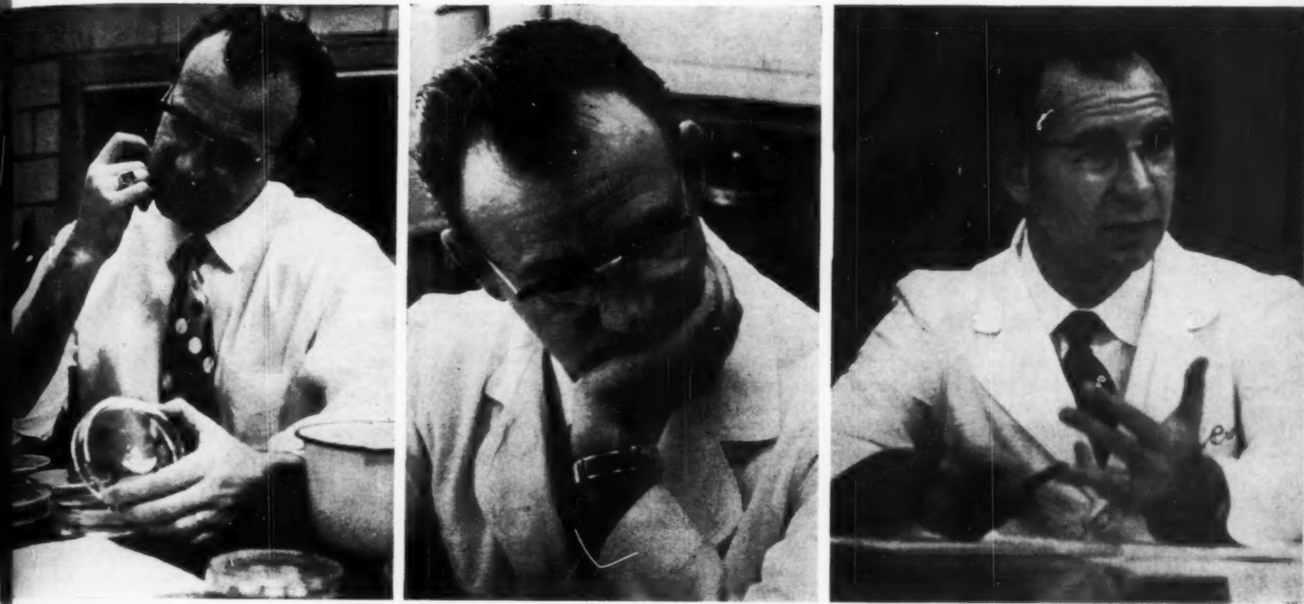
It was in a somewhat indirect way that his interest in science was kindled. His elder brother had priority to their father's workshop. Sorely disappointed, the younger boy literally took to the woods. There, in the great outdoors, he found to his wonderment things that were even more fascinating than the workshop. Living creatures touched his imagination, and he began to marvel at the processes of life. A chemistry set intrigued him, and he persevered to become a student of organic chemistry. Combining his interest in chemistry with his early interest in living things, he took his Ph.D. in biochemistry. As *Dr.* Probst, he left the University of Minnesota in 1950 and came to Lilly.

## First project

His first project was to work out a patentable chemical process to help Lilly compete with other pharmaceutical companies in the field of vitamin



*Adapted from an article that appeared in* The Lilly Review.



— Eli Lilly and Co.

$B_{12}$. Later, while working in antibiotics screening, he quite by chance moved into the field of cancer research. As he describes it:

"One of our crude forms of antibiotic was sent to the Sloan-Kettering Institute for Cancer Research, where it was found to exhibit very strong anti-cancer activity. At that time, very few anti-cancer substances were known at all, and I expressed my desire to work at isolating the active principle. I had no idea what I was in for. Like most antibiotic broths, this one contained a multitude of contaminating substances — thousands of them, for all I knew. For three years, I worked on it. Although I was doing other research at the same time, my co-workers came to know me by the assigned number of that stubborn substance; I was called 'Operator 19999.' We finally exhausted all our techniques for purifying the material and were forced to set it aside for the time being.

"It was discouraging to have to shelve such promising material, but by then my interest in cancer was really deepening. I was asked if I'd like to direct my attention to the subject and keep up to date on world-wide research activities.

"This was an intriguing prospect. As well as concerning millions of human lives, it raised the basic questions of life and growth — in single cells and whole animals, normal and cancerous. If we knew everything about cells — all the processes going on inside them, their interaction with neighboring cells, and, in fact, their relationship to the whole animal — biochemists would go out of business and cancer would be a thing of the past. But I feel that it's going to take years of search and struggle to discover all the thousands of tiny links and fit them together to make sense.

"Our cancer-screening is one way to gather bits of information, but, primarily, it is done in the hope of suddenly discovering a really terrific anti-cancer drug. It's a fabulous undertaking, involving thousands upon thousands of tests. It's expensive, it's tedious, it's even wasteful. Yet it needs to produce only *one* worth-while substance to prove itself. Screening systems have proved tremendously successful in discovering antibiotics and other drugs, insecticides, and so forth, and I can think of some reasons why the same might be so in our cancer work.

## Questions of nature

"What this kind of research amounts to is the setting up of conditions that allow us to ask a question of nature and receive an answer. In its simplest form, we ask: 'Will this fermentation broth prevent a transplanted tumor from taking root, growing in, and destroying these mice?' "

The best place for Dr. Probst to show an anti-tumor agent in action was in the animal laboratory where there was one at work. The laboratory seemed to be something of a menagerie, with cages of different sizes stacked along the tile walls and in the center of the room. There were mice, monkeys, guinea pigs, rabbits, and roosters. Dr. Probst made a reasonable attempt to explain what was happening to the mice, while the roosters insistently punctuated his sentences. He held up two mice. Both had received transplanted tumors, but only one had been treated with a preparation containing anti-tumor activity. The treated mouse looked normal. The untreated one had a huge, malignant growth that had swelled its abdomen to twice the size of the first mouse's.

"In this kind of test," he said, "we use what might be called 'immortal tumors.' Since cancer is actually many different diseases, tumors act in many different ways and give us a great deal of difficulty. In order to standardize the tumors for our tests, we transplant cancerous cells from mouse to mouse, thus literally using the same tumor in

all the mice. One of the big drawbacks in the system is that, out of necessity, we are dealing with tumors in mice while we are attempting to cure tumors in man. The relationship between mouse and human tumors simply isn't known.

"Let's look at the problem this way: Because of our lack of fundamental knowledge, we devise a system that we hope will sift out some compounds to do the job we want done. Then we want to purify an active compound, find out how it works, and see whether it will destroy cancer cells without harming normal cells in humans.

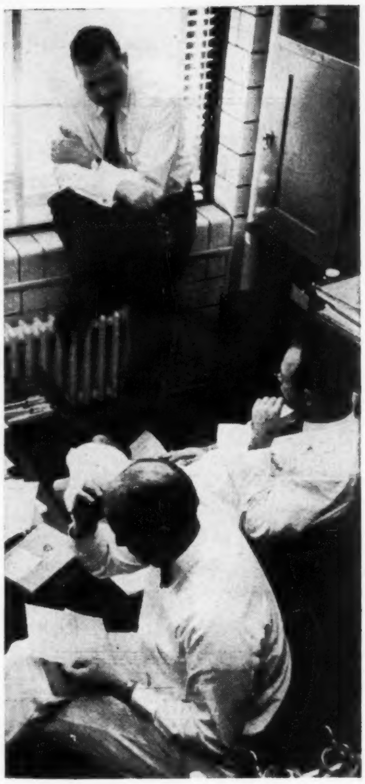
"In many respects, my job is a constant process of developing new approaches and new ideas. Often, I reach a particularly tough stumbling block and just don't have any ideas. It gives me a lost, vacuous feeling. At these times, I find it best simply to set aside the problem and do something else. I may go to the library and read a scientific journal, or I may talk to the fellow in the lab next door, or I may sleep on it. These things seem to help me get out of the rut and crystallize new ideas."

Although cancer research is the main part of his work, Dr. Probst has other projects that are not nearly so complex. "They aren't necessarily simple problems," he said, "but it's a good feeling to be able to finish them in a relatively short time. Not long ago, for example, I was working on a project with the goal of obtaining crystalline gibberellic acid simply and economically. After nine months, methods were devised that were both useful and novel and that permitted us to make patent applications."

A telephone call came through for Dr. Probst. Shortly after the call, a physical chemist dropped into the laboratory to discuss a problem.

"You see," said Dr. Probst, after the other chemist had left, "questions are always coming up — questions that must be answered if we're to succeed at what we're doing. This reminds me of a prominent scientist who, earlier in this century, said that everything of importance in physics had already been discovered and that the field was essentially dead. Well, here we are in the age of atomic energy and rocketry, and physics is a booming science. Every answer seems to lead to another question or problem.

"As a scientist looking for both answers and questions, I run through a whole gamut of emotions. From day to day, or even from hour to hour, I'm hopeful or doubtful, satisfied or disappointed, happy or unhappy. I guess these are feelings almost everybody has in his daily work. One thing I don't want to do is accept all scientific theories on blind faith. It might be easy, or even comfortable, to do this, but it's not satisfying and it's certainly



not the way to progress and better living."

# Yours for the asking

Two brief and to-the-point pamphlets are put out by the American Cancer Society. *Why Learn about Cancer?* defines the disease, lists danger signals, and tells how you can help fight cancer. Some of the questions pertaining to smoking and incidence of lung cancer are discussed in *To Smoke or Not to Smoke?* Both pamphlets are available from your local office of the American Cancer Society, or check No. 10281 and/or No. 10282 in the coupon below.

*The Edison Effect* is a factual history of electronics that traces the development of this science from the discoveries of Thomas Alva Edison, the Fleming valve, and audion through the contributions of William D. Coolidge, Irving Langmuir, Robert A. Millikan, and Vladimir Zworykin. From the Thomas Alva Edison Foundation; 72 pages. Check No. 10283.

The 29 questions most often asked about the electric industry are answered in *I Want to Know about the Electric Industry*. This booklet, published by the Edison Electric Institute, contains 32 pages and almost as many charts, answering such queries as: What are electric power companies doing to develop atomic energy? What about electricity on the farm? How does steam plant generation compare with water power? Check No. 10284.

Chas. Pfizer & Co., Inc., designed *Our Smallest Servants* to tell the story of fermentation. This handsome, full-color booklet describes the discovery of penicillin and consequent production of antibiotics. It also contains a chart that illustrates the step-by-step method of producing Terramycin. Bibliography. Check No. 10285.

Check your choice, clip coupon, and mail to: **Yours for the Asking, Science World, 575 Madison Avenue, New York 22, N. Y.**

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- ☐ 10283 The Edison Effect
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- ☐ 10285 Our Smallest Servants

See also: pages 2, 30, 32

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PLEASE PRINT

**Science fiction**

***The story to date:***
*Mr. Binder has invented a solid vacuum, which "throws away" all matter it comes in contact with. However spectacular the invention, it seemed useless until Mr. Madden came along, complaining about the expense of putting a new engine in his fishing boat. Then Mr. Binder had an idea — solid vacuum painted on the bow of the boat would pull it along*

# Mr. Binder and the solid vacuum

**By Murray Leinster**

CONCLUSION ● Mr. Binder painted the first of the two coats on an old sail stretched about the *Gertrude's* bow. When that had dried, he would swab it over with a particular reagent, and the sail would be coated with solid vacuum. The *Gertrude* was an ancient, stubby craft some forty feet long and something over twelve feet wide. She rested rakishly, stern to shoreward, on a cradle on a marine railway. About her there lay a thick aroma of oakum, paint, discarded bait, salt-water mud, and general effluvium. She fitted her background. The canvas about her bow looked like an untidy diaper, and it was held in place by stout roofing nails. Mr. Binder carefully refrained from preparing his solid-vacuum surface all the way back to the nails, in case he needed to take the canvas off again. Mr. Madden sat on her deck underneath the awning-frame.

Mr. Binder tested the first coat of his infinite-surface-tension solid-vacuum material. He swabbed it over with the reagent. He climbed a ladder leaning against the *Gertrude's* hull. Mr. Madden greeted him blithely.

"Well, can we try it now?"

Mr. Binder went forward and held his hand over the rail. He felt a distinct breeze blowing upward — air hurled sideways by the solid-vacuum coating just completed. If he'd put his hand astern from the side coating, he'd have found air blowing astern, or if he'd put his hand underneath the bottom of the solid vacuum he'd have felt wind there, too. The stuff wasn't particular which way it heaved things. It just heaved them sideways to avoid their contaminating touch. This went even for air. It should go also for water. Mr. Binder went astern and nodded.

"I think it'll be all right to try now, George," he agreed.

Mr. Madden went ashore to the office of the marine railway. He arranged for the cradle bearing the *Gertrude* to be lowered gently until the bow of the boat barely rested in the water. He climbed to the deck again, went into the pilothouse, and waved instructions.

The person in charge of the winch that hauled the cradle negligently reached down and lifted over the ratchet of the winch. The winch thereupon turned deliberately and whacked him in the solar plexus with a capstan bar. He sat down, gasping. The *Gertrude* trundled down the inclined ways toward the water.

"Hold it!" roared Mr. Madden. "Slow, now! Easy!"

The *Gertrude* went rolling faster. Mr. Madden bellowed instructions. They were wholly futile. *Gertrude* and all, the cradle splashed into the water. Wavelets reached up with a pretty eagerness to play tag with the charter-boat's bow.

When water tried to touch the canvas-covered bow, it was flung violently aside. It went in all directions in a thin, glistening, high-velocity sheet. When the *Gertrude* hit water, there appeared about her front parts something that looked singularly like a liquid pinwheel twenty feet high. That was the water getting away from before the boat and leaving a vacuum there. Nature abhors a vacuum. So did the *Gertrude*. She tried to move into the vacuum and to fill it. The vacuum moved on before. The *Gertrude* hastened, flinging water higher and wider in her haste. The vacuum moved still faster, being fastened to her.

The *Gertrude* went out of the slip leading to the railway exactly like a bolt of greased lightning.

She had never made more than a groaning eight knots in all her existence before, because her bow was bluff and clumsy and plenty of power was needed to overcome its resistance. It offered no resistance now. There was nothing ahead of it. She was making thirty-seven knots when she got out of the slip and headed for a sand-barge in tranquil passage to some unknown destination. When Mr. Madden in the pilothouse recovered from the paralysis of terror, he swung the wheel, but fast. The *Gertrude* heeled dangerously and missed the sand-barge by six inches. She started down the harbor to pick up some speed.

At the very beginning, when she was going under fifty knots, she looked rather like a fireboat with all hoses working. But, of course, fireboats don't usually travel quite that fast. At somewhere between fifty and sixty knots, the *Gertrude* began to look more impressive. Spume and spray flung from her bows rose to a height of sixty feet or better — the height of a six-story building — and spread out on either hand. And there was plenty of water hitting her bows now, and every drop of it went somewhere. Some doubtless spurted down toward the bottom of the harbor. Some of it flowed astern. But an awful lot went into the air. There was something like six thousand tons of water thrown up to become air-borne spray for every mile she traveled. And did she travel!

*Adapted, by permission of the author, from a story that originally appeared in* Startling Stories *for October, 1953; copyright 1953 by Better Publications, Inc.*

From the *Gertrude's* pilothouse, nothing whatever was to be seen. She was surrounded by walls of rushing water — rising water, thrown away sideways by the solid vacuum at her bows. And the rising streams moved at such high velocity that they broke into tiny and ever tinier droplets and then into the tiniest particles, until they were so small that they did not fall again. They were fog particles. They floated in the air like the world-famous mists of Niagara.

The *Gertrude* was blinded. She was invisible. A monstrous half-cylinder of vapor raced across the harbor, and it engulfed this ship and that, and no man knew what it could be, but all men feared it. Within the column — right behind that startling tumult — Mr. Madden uttered stricken cries and wrestled with the *Gertrude's* wheel.

There was a tug towing a long line of log rafts down toward the sea. The lightning-like rush of white vapor roared upon the rafts. The *Gertrude* hit them. Her bows growled. The wooden rod had burped politely on hitting wood. The solid vacuum before the *Gertrude* made a deep bass note as it flung aside the separate particles of log that tried to make physical contact with it. The tug sped on, its foremost raft sliced through in the mist.

The straight line of the *Gertrude's* progress broke as she was heading for a wharf. Mr. Madden clawed her around, and she heeled and made a ten-foot wave to go on and make trouble where it hit. She rushed toward an anchored tramp and actually did pass under the overhang of its stern, and she pushed the tramp's bows underwater by the violence of her upward thrust. She swerved again as Mr. Madden turned her wheel at frantic random. She was throwing water upward at the rate of hundreds of tons per second, and she ran across the bow of a ferryboat and drowned its fires and half-drowned its passengers.

"Turn it off!" howled Mr. Madden. "Turn it off! We've got to turn it off!"

They were isolated from all of mankind in a universe of white mist. Mr. Binder said, "We can't."

Then the world went black about them. It was not that they were unconscious. It was that the *Gertrude* had gotten into the shallow water near shore, alongside the elegant and expensive shore-road section of the city. She was plowing through three feet of black mud. But it offered no hindrance to her passage. She threw it away with a continuous gesture. The *Gertrude* hit ninety knots traveling through mud some fifteen yards from shore. She heaved mud up; it floated magnificently over the roadside at the water's edge; it coated trees, shrubs, houses, windows, and the elegantly attired strollers on the shore road. And Mr. Madden twisted madly at the wheel and veered out, cut through the stern of a low-lying garbage-scow on its way to sea, and flushed all the more malodorous refuse off it into the harbor. Then the *Gertrude* streaked for the area thick with maritime traffic.

It should be understood that in all this Mr. Madden was going it blind. He was surrounded by an impenetrable white mist, stories high and half a block thick — the thickest fog that ever was, on land or sea. He continued to wrench at the steering wheel and howl for Mr. Binder to turn off the vacuum. Meanwhile, the *Gertrude* cut circles and figure-eights and arabesques in the water. She swamped a small boat carrying a party ashore from a battleship. She swerved into a sandbar and sent a saffron cloud aloft. She ran under a bridge so close to one of its piers that Mr. Madden saw the mass of masonry an arm's length away, even through the mist.

The stream of vapor she left behind did not settle. It was too fine. And the *Gertrude* ran crazily here and there and everywhere, leaving monstrous masses of mist behind her, and all harbor traffic ceased to move. Ships cast anchor and unlimbered foghorns. Tugs blew whistles. Smaller craft rang bells, and bedlam arose upon the face of the waters.

Mr. Binder crawled aft and went into the pilothouse.

"Turn it off!" howled Mr. Madden, as the bowsprit of a sailboat at anchor poked into view in the mist, caught in the pilothouse window, and neatly pulled one side of that small structure loose and carried it astern. "Stop it! Cut it off! Do something!"

The *Gertrude* howled between the sterns of two ships that were drifting together, and steel plates met and crashed over head. Mr. Madden wrenched at the wheel and wailed: "Sink her! We've got to stop! Sink her!"

Mr. Binder said mildly, "That's what I came to tell you about, George. She is sinking. I suppose there was a plug left open to drain her when she was up on the railway, and she's filling up." Then he added painfully, "It worries me, George. Because if we jump overboard, going as fast as this, we'll be knocked unconscious and drown. And when she starts to sink she's going to point bow downward,

most likely, and head for the center of the earth. And we can't get out."

Mr. Madden opened his mouth. His eyes stared. Then he fainted peaceably.

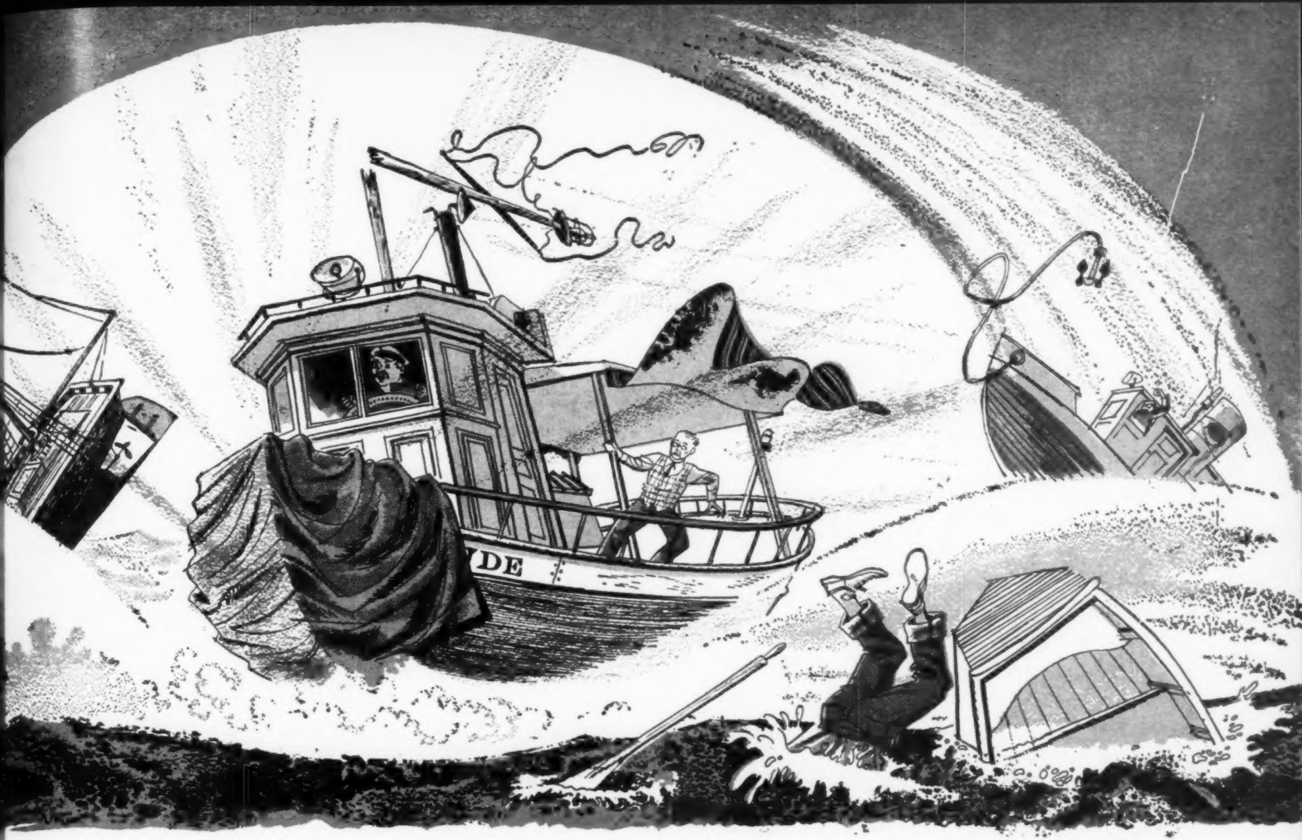
When he recovered consciousness, there was a great quietude all about. The sun shone brightly. Waves lapped gently somewhere. Birds sang.

He heard a ripping sound. It sounded like somebody tearing more or less rotted canvas. It came again. Mr. Madden realized that the *Gertrude* was perfectly still. She did not rock, she did not have that faintly stirring, alive feeling, which all boats possess.

Slowly, groggily, incredulously, Mr. Madden staggered to his feet. He did not have to go through the pilothouse door. A wall was missing, providing a more convenient exit.

He stared blankly about him. The *Gertrude* was ashore on a slanting, sandy beach. There was no sign of civilization anywhere, save a rusty tin can half-buried in the salty sand. Mr. Madden recognized his whereabouts. This was one of the Beach Islands, forty miles down the coast from the harbor in which the *Gertrude* had broken all records for speed and the creation of tumult.

The ripping of canvas came again. Mr. Madden tottered along the *Gert-*




Illustrated by Paul Granger

*rude's* deck. He looked over her bow. Mr. Binder stood on the beach, ripping off the canvas that had been coated with solid vacuum. He was handling it very carefully — only from the uncoated side. When he got a good-sized piece of it loose, he struck a match to it. It burned brightly. Mr. Madden croaked: "Hey!"

Mr. Binder looked up and beamed at him. "Oh. Hello, George. We're all right, you see. When you fainted, George, I took the wheel. It looks like I very fortunately steered right out of the harbor and to sea. But when the *Gertrude* slowed down I made out where we were and steered accordingly."

"Slowed down?"

"Yes," said Mr. Binder mildly. "I didn't realize it, but it was very fortunate about the engine. When the *Gertrude* started to sink, the engine made her stern sink deeper than the bow. The bow started to come out of the water. There wasn't so much of the vacuum in the water, and it didn't pull so hard. So we slowed.

"I headed along the coast," Mr. Binder explained, "until we were slowed away down. Then I headed for shore. We were almost sunk then, and the bow hardly touched water. I hit the beach not going too fast, and we just went up a little way. We'll have to get a tug to pull the *Gertrude* off, but I don't think she's damaged.

"I thought I'd better get this canvas off," said Mr. Binder apologetically. "Somebody might come along and touch it, not knowing. But I made an interesting discovery, George! I think it'll please you. I don't think it's quite practical to use my solid vacuum as a way of pulling the *Gertrude* along, but I've got something just as good."

Mr. Madden swept his eyes heavenward. Then he looked dazedly along the beach. He saw a rather heavy stick of driftwood at the edge of the waves.

"I'll tell you," said Mr. Binder interestedly. He held a strip of canvas — coated with solid vacuum — in his hands. He very carefully touched the back, the non-coated part only. He had it doubled so he could hold it. "See?"

Mr. Madden was speechless.

"The solid vacuum," said Mr. Binder, "won't let anything touch it. Friction can only happen when two things touch. And the solid vacuum throws away anything that touches it, but it won't throw away another solid vacuum! Because that can't touch! See? So if I have two solid-vacuum surfaces, George, and I rub them together, I have absolutely frictionless sliding!"

He beamed at Mr. Madden.

"I'll tell you, George," he said happily, "all the stuff to make solid vacuum is on board. You go and get a tug to pull the *Gertrude* off, and pump it out and plug the hole in it. And while you're gone I'll take the engine apart. And I'll coat the inside of the cylinder and the outside of the pistons with solid vacuum, and I'll coat the bearings and the things that run in them. And then the engine will be absolutely frictionless. You won't need a new one, you'll save money . . ."

He stopped. Mr. Madden descended with great deliberation from the deck of the stranded *Gertrude* to the sand. He walked away from Mr. Binder. He picked up a heavy stick of driftwood from the edge of the waves. He started back for Mr. Binder, swinging it . . .

He didn't catch Mr. Binder. Humanitarianism aside, it may be a pity. We could all feel much safer if he had. Because Mr. Binder does "research." Right now he is working on the idea that two and two has only been observed to total four in a long sequence of what may be coincidences. He is investigating the theoretical possibility that two and two might some day produce five. It sounds harmless, but nobody can guess what Mr. Binder will accomplish.

It's the suspense that hurts.

# On the light side

## Brain teasers

### Lady on foot

A ladybug crawls along a ruler from the 12-inch mark at one end to the 6-inch mark in the center. It takes her 12 seconds. Continuing on her way, she crawls from the center to the 1-inch mark, but this takes her only 10 seconds. Can you think of a good reason for the time difference?

### Pair the hair

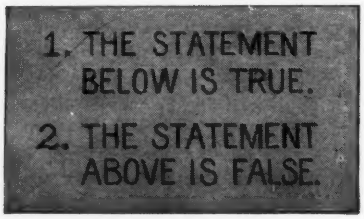
There are more dogs in the United States than there are hairs on any one dog. Prove that at least two dogs in the country have exactly the same number of hairs.

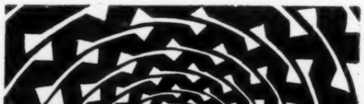
## Liar paradox

The two statements below seem innocent enough, but you are likely to develop a headache if you think about them. If the first statement is true, then the second must be true. But if the second is true, then the first must be false. However, if the first is false then the second must be false also. Therefore the first must be true!

This is a modern form of the "liar paradox," which the ancient Greeks expressed as follows: "'All Cretans are liars,' declared Epimenides the Cretan." Like the previous paradox, this statement plunges you into a bottomless whirlpool of contradictions.

Paradoxes of this sort are not trivial. They have played important roles in modern mathematics and symbolic logic. Logicians today avoid the paradoxes by refusing to permit a logical language to talk about the truth of its own statements. Such talk must occur in a higher language called the "metalanguage." It is interesting to note what happens when the liar paradox is fed to an electrical logic machine. The machine goes into an oscillating phase, switching rapidly back and forth between true and false for as long as the current lasts or until the machine suffers a "nervous breakdown."



## Spooky spiral

Would you doubt that the picture above shows a spiral line twisting out from the center? Trace any portion of it with the point of a pencil, and you'll discover that it is not a spiral. It is a series of concentric circles!

This remarkable optical illusion belongs to a class known as "twisted-cord illusions." They may be produced by twisting together a black and a white strand to make a single cord, then placing the twisted cord on variously patterned backgrounds. There are many theories, but there is no general agreement among psychologists as to why these illusions deceive the eye.

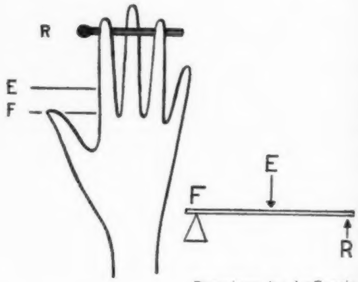
## The unbreakable match

Hold a wooden kitchen match with the tips of your fingers, as shown. Try to break it. You'll be surprised to find that it can't be done.

This is easily understood when you realize that the muscles of the hand move the fingers in the manner of a third-class lever. Such a lever is one that has the fulcrum ($F$) at one end, the resistance ($R$) at the other end, and the effort ($E$) applied somewhere in between. Tweezers and sugar tongs are common examples.

This type of lever sacrifices power for a wider arc of movement at the resistance end. The longer the distance from the resistance (in this case, the match) to the fulcrum (base of finger) as compared to the distance from the effort (where the muscle is attached) to the fulcrum, the less the "mechanical advantage" of the lever. If you slide the match closer to the base of the fingers, the mechanical advantage increases enormously. Then the match can be easily snapped.

— George Groth




Drawings by LoCurcio

## Answers

LADY ON FOOT: The ladybug moves at a constant speed of 1 inch every 2 seconds. Did it occur to you that the distance from the center of the ruler to the 1-inch mark is only 5 inches?

PAIR THE HAIR: If no two dogs have the same number of hairs, then each must have a *different* number. Suppose one dog has 1 hair, another 2, another 3, and so on. When you reach the maximum number of hairs possible, there will still be at least one dog left, for there are more dogs than hairs. And this dog must have a hair count matching one of those previously considered.

## Answer to 'Will It Work?'

Such electromagnets have been built, and they do indeed work. Some have been able to hold iron weights of more than ¼ ton! Their low efficiency, however, makes them little more than laboratory curiosities. They are used to demonstrate thermoelectric emf and the unusual application of Ohm's law. These electromagnets can be bought from scientific supply houses.

## TELL US ABOUT IT

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**Will the average length of human life continue to increase?**

In America, the average life span has increased from 48 to 70 years since 1900. Dr. Louis I. Dublin of the Institute of Life Insurance expects that there will be a further slow increase to about 75 years, as the diseases of the later years are conquered. Babies born this year have an even chance of living to the year 2030. Some authorities think that an average life span of 80 years is possible, with many persons living beyond the age of 90. But there is no expectation that more than a very few will ever reach the age of 100 years.

**Why was the zero of the Fahrenheit temperature scale placed so high that we have below-zero weather?**

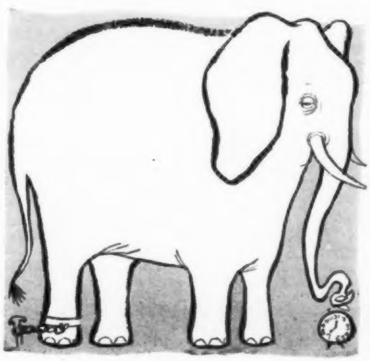
When Gabriel Daniel Fahrenheit devised the scale, he set the zero at the lowest temperature he could produce with mixtures of ice and salt. He set the 96° point at what he thought was the temperature of the human body. Both points were inexact and illogical in modern terms. The centigrade scale is preferred in science, because its two standard points are exact: zero stands for the freezing point of water and 100° for its boiling point.

**Is there a "youth hormone" to keep people young?**

No, but there's one that keeps insects immature. Dr. Carroll M. Williams of Harvard University has extracted tiny amounts of this hormone from the ground-up abdominal tissues of the *Cecropia* moth. The hormone is actively secreted during the moth's larval (or caterpillar) stage. When the secretion stops, the larva responds to a growth hormone and changes into a pupa (intermediate stage). But if the "juvenile hormone" is injected, the larva does not change into a pupa right away. It remains a caterpillar, growing to a giant size. It then changes into a giant pupa, and the pupa into a giant moth. Thus, the hormone not only keeps the insect immature longer, but also increases its size.

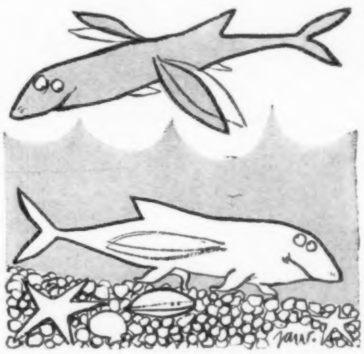
**Do all animals sleep?**

Since "sleep" is difficult both to define and to measure, the answer is uncertain. It's especially uncertain for insects and other invertebrates. It is known, though, that insects have periods of inactivity resembling sleep. As for vertebrates, reptiles seem to get relatively little sleep, in the sense of unconsciousness. And fish go without sleep for long periods. A shark in the aquarium at Sydney, Australia, for example, has gone without sleep, as we know it, for six years. But warm-blooded mammals all need some sleep. The amount is related to the rate of the mammal's heartbeat and its size. White rats, which may have as many as 500 beats per minute, need twelve or more hours of sleep a day. In contrast, elephants have a pulse beat as low as 25 and need only two or three.



**Can fish walk or fly?**

Flying fish use their extended fins to glide. Some can glide for more than 13 seconds at 35 miles per hour. But since the fins have no muscles, they cannot flap as bird wings can. Many fish use their fins to walk along the bottom of a body of water. The fins are equipped with muscles for this purpose. Only a few fish have muscles strong enough to allow them to walk on land. One, the climbing perch, has been observed to walk as far as 300 feet in 30 minutes, going from one pool to another. And, on rare occasions, this fish has been known to climb the trunks of trees.



**Do islands ever actually "rise out**

When undersea volcanoes erupt, the material they eject frequently builds up to a point where it is above the surface of the water. In a similar manner, Mount Parícutin in Mexico was recently built up on a cornfield. Even without volcanic action, some islands rise. For example, the large arctic island of Spitsbergen, far north of Norway, is rising out of the sea at a rate of almost an inch a year. As a result, the bones of whales left on the beaches 300 years ago are now from 15 to 25 feet above sea level and, in some places, half a mile inland. This rise is caused by the melting of the ice cover, now 500 feet thick. As in the case of other land areas of the world, the island floats, so to speak, on a hot, almost-liquid layer of rock about 25 miles below the earth's surface. Thus, as the weight of the ice on top of it is reduced, the island rises.

— Gerald Wendt

*Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.*

# Science teacher's question box

**How can I inflate a balloon with hydrogen produced by a simple bottle-type hydrogen generator? — R. G., Chicago, Ill.**

First, since synthetic rubber balloons are difficult to inflate, stretch the balloon in all directions. Connect a two-way hand pump from the delivery tube to the balloon. The input (or vacuum) side of the pump goes to the generator, while the pressure side goes to the balloon. Make certain that no flames or sparks are present in the room. (For another way to fill balloons with gas, see "Shop Talk," October 14 issue.)

**How do you measure the half-life of a short-lived radioisotope such as iodine 131 or phosphorus 32? — B. W., Cambridge, Mass.**

Use a standard Geiger counter. First, note the background count in counts per minute. Then place the test probe (Geiger tube) one inch from the isotope. Keep it in this position for two weeks, taking daily readings. Uncover the isotope only during a reading. (Make sure that no radium watch dial or other radioactive source is brought near the probe.)

Subtract the background count from each total daily count. Plot the counts against time on semi-log graph paper. (Note: the AEC will send on request a list of companies from which you can purchase isotopes in small amounts.)

**What are some simple vitamin tests that can be performed in the classroom? — A. H., New York, N.Y.**

Tests for vitamins A and C are the only ones simple enough to be conducted in class. To test for vitamin A, take a vitamin capsule containing pure vitamin A. This may be obtained in a drugstore. Break the capsule, and put the contents in a test tube. Add 1 cc. of carbon tetrachloride. Since carbon tetrachloride fumes are toxic, do this by an open window or in some other well-ventilated place. (Ether may also be used in a well-ventilated room, although it is, of course, explosive and flammable.)

Now, with a pair of tweezers, drop in one small white crystal of antimony trichloride (about 1/4 inch in size). The contents will turn purple-blue, indicating the presence of vitamin A. Pour the contents into a drain and flush. Do not handle the crystal with the bare fingers.

Next, test samples of mixed vitamin A in the same manner.

To test for vitamin C, obtain a dye called sodium 2,6-dichlorobenzenone-indophenol from a chemical or scientific supply house. A fraction of an ounce of the powder will make pints of test agent. Dissolve the powder in ordinary tap water. A blue dye forms. Then, obtain samples of 10 per cent ascorbic acid solution (vitamin C). One type is called "Cecon." (Or buy vitamin C pills. These must be properly dissolved and diluted.)

Now take the 10 per cent solution and dilute with nine parts of water to make approximately a 1 per cent solution. To this solution of vitamin C, add, with a medicine dropper, one drop of the blue dye at a time. The blue dye will become clear and colorless. Determine how many drops of blue indicator can be put in the 1 per cent vitamin C solution before the solution begins to color. This number of drops is your standard for 1 per cent of vitamin C.

Test various citrus juices in the same way. The number of drops will indicate the fraction of 1 per cent of vitamin C present.

Another technique is to use Lugol's solution (iodine in water) instead of the blue dye. Here, the brown color will become clear. Or you can mix starch with iodine to make a blue starch iodide suspension. This will also become clear in vitamin C.

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# Shop talk

Many of the conventional methods of having students test salts to see whether they undergo hydrolysis utilize litmus paper as the acid-base indicator. But there's a more effective method, reports A. J. Crossfield of San Juan High School in Citrus Heights, California. He recommends the use of semi-microlaboratory procedures and Universal Indicator solution (preparation described below).

After Mr. Crossfield's students study acids, bases, ionization, and the writing of ionic equations, he presents the following demonstration and questioning to the class:

"I have in this jar a white, solid sodium compound," says Mr. Crossfield. "As you see, it dissolves readily in water. I also have a tube of water to which I add a few ml. of Universal Indicator. Observe the green color. Now let's add some of this dissolved sodium compound to the indicator solution. Observe the strong violet color. What is the sodium compound?"

Of course, many students quickly reply, "Sodium hydroxide."

"Wrong," says Mr. Crossfield. He waits for other answers. After a short silence, students try again.

"Sodium oxide?" one may ask.

"Wrong again," says Mr. Crossfield.

"But that's the only common sodium base."

"Right," he says. He then asks where they got the idea that salts are all neutral. He suggests that the class had better learn more about this before going on to other studies.

He next carries out the following experiment as an appropriate learning experience:

"In their semi-microreagent trays, the students have at least fifteen different water-soluble salts that can be tested. These include sodium carbonate (which, of course, was the white sodium compound presented in the opening demonstration) and such other salts as ammonium chloride, potassium nitrate, aluminum sulfate, zinc sulfate, borax, sodium bicorbonate, cupric sulfate, sodium phosphate, and ferric chloride. The students dissolve a pinch of a salt in one ml. of water. Then they add a few drops of this solution to about three drops of Universal Indicator in a depression in a spot plate or on a watch glass or glass slide. It is extremely easy to record the approximate *p*H of the solution to the nearest *p*H unit.

"On the following day, explanations for the behavior of the salts are developed."

Mr. Crossfield prepares the Universal Indicator as follows: In 100 ml. of 95 per cent ethyl alcohol, dissolve the following dyes: thymol blue (0.005 g.), bromothymol blue (0.06 g.), phenolphthalein (0.10 g.). Neutralize to green with dilute NaOH and make up to 200 ml. volume with distilled water.

The color of the indicator and the corresponding *p*H values are:

| *p*H | Color |
|---|---|
| 4 | red |
| 5 | orange |
| 6 | yellow |
| 7 | green |
| 8 | blue |
| 9 | indigo |
| 10 | violet |

# How to do it

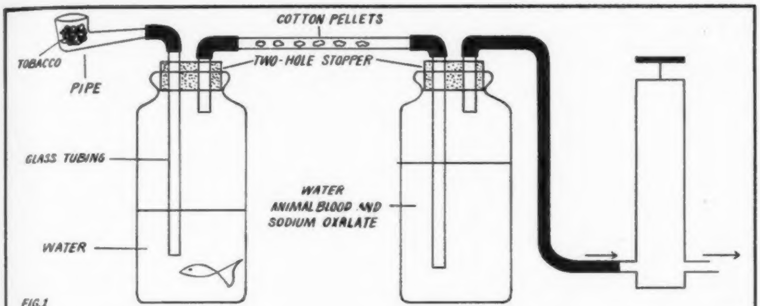

FIG.1

## Demonstrating tobacco's harmful effects

A rather striking classroom or auditorium demonstration of the effects of nicotine on a living organism can be carried out with fairly simple apparatus as shown in Fig. 1. A live goldfish or a frog is placed in the water in the milk bottle at left. Either a clay soap-bubble pipe or a real smoking pipe may be used. Clear plastic tubing may be substituted for the glass tubing. In the one-foot-long tubing connecting the bottles, pellets of absorbent cotton are inserted. (Make certain that the tube is not blocked by the pellets.) The milk bottle at right contains water, animal blood (obtained from a butcher shop), and sodium oxalate (to prevent clotting). This bottle is connected by a rubber tube to the input (vacuum side) of a two-way hand pump (or to the "suction" side of an aspirator connected to a faucet).

Now for the demonstration. Ignite the tobacco in the pipe and make it smoke by the action of the hand pump or the aspirator. Smoke will bubble into the first bottle. After a while, the fish or frog will become sick. Remove the animal immediately. Tobacco tars will collect on the cotton pellets. The blood in the second bottle will turn brighter red due to the carbon monoxide produced by burning tobacco.

Next, remove some of the tar from the cotton pellets with tweezers. Place the tar on a frog's tongue. (If a frog was used previously, do not use the same animal.) The frog will immediately be poisoned by the nicotine.

Perhaps this series of demonstrations may prevent some youngsters from smoking. In addition, the teacher may want to point out that these same tars contain the agents that have been attributed by many medical researchers as being one possible cause of human lung cancer.

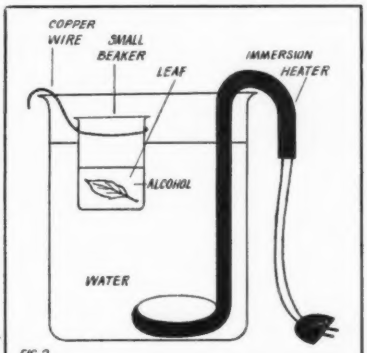

FIG.2

## Safe extraction of chlorophyll

A photosynthesis demonstration in general science or biology class can be hazardous. The hazard lies in the extraction of chlorophyll from a green leaf before the starch test is made. The leaf is boiled in alcohol, which is usually heated in a water bath by a Bunsen burner. But in some cases, the evaporating alcohol fumes have ignited. Some teachers therefore heat the water bath on an electric hot plate. A still safer technique involves using an immersion water heater. This technique is absolutely ignition-proof.

The apparatus used in this technique is set up as in Fig. 2. The immersion heater will operate on 110 volts A.C. or D.C. from a wall outlet. The small beaker is suspended from the top edge of the large beaker by a stiff copper wire. In the small beaker are several ounces of alcohol (rubbing alcohol will do). Even if alcohol is deliberately poured on the heating unit, no ignition will occur.

In extracting the chlorophyll, of course, the leaf is first partly covered with cork and exposed to sunlight for an hour or two. On a cloudy day, it can be placed under a 200-watt lamp, though not so close that the leaf overheats. The leaf is now boiled in water until its cell walls break down and it becomes soft. Then the leaf is transferred with tweezers into the alcohol, which is heated. When the alcohol turns green, it is dumped out, more is added, and the process repeated, so the last traces of chlorophyll can be extracted.

A geranium leaf is commonly used in this demonstration, but for quick results (fifteen minutes of sunlight will do), use Golden Bedder Coleus.

## Homemade immersion heater

In classrooms where there are no gas or electrical facilities for heating water for experiments, the following device has been found useful by many teachers. All that is needed are two large carbon rods taken from dead dry cells. Remove the carbon rods so that the binding post on top of each is intact. Do this over a newspaper, since the black manganese dioxide in the cell can make a mess and can mark up the floor. Heat the carbon rods over a gas stove flame to drive out any waxes that may be present.

Now separate the two rods by spacers, as shown in Fig. 3. The spacers are small pieces of ¼-inch thick wood. Fasten the rods together with rubber bands or with electrician's rubber tape. Connect one wire of an electric lamp cord to each terminal. At the other end of the lamp cord, attach an electric plug.

Place the rods in a beaker or jar, and add a few grains of common salt. Then add water. Plug the lamp cord into a wall outlet, and the water will heat. Increasing the salt content will increase the heating rate. *Warning: to avoid electric shocks, make sure that no one places his fingers in the water while the unit is connected to the current.*

Place samples to be heated in test tubes resting in the salt water.

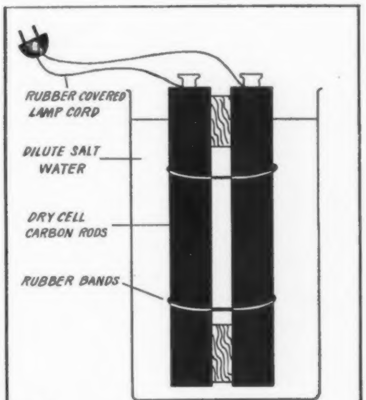

FIG.3

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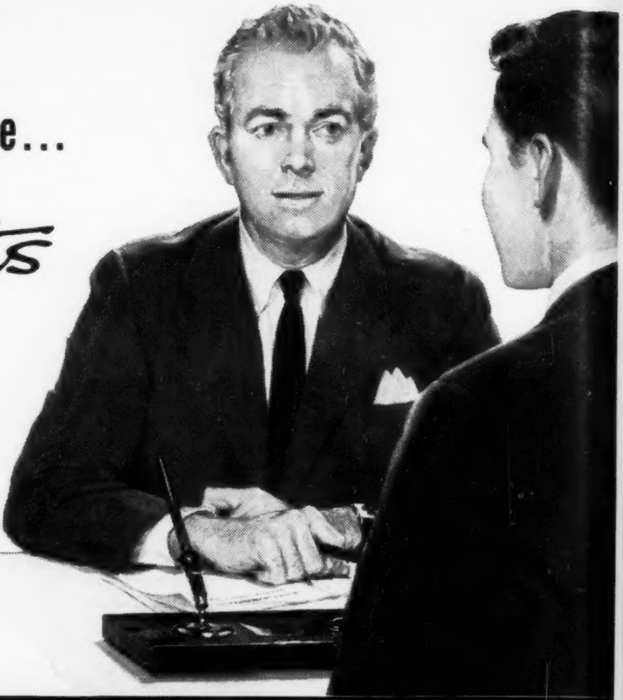

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